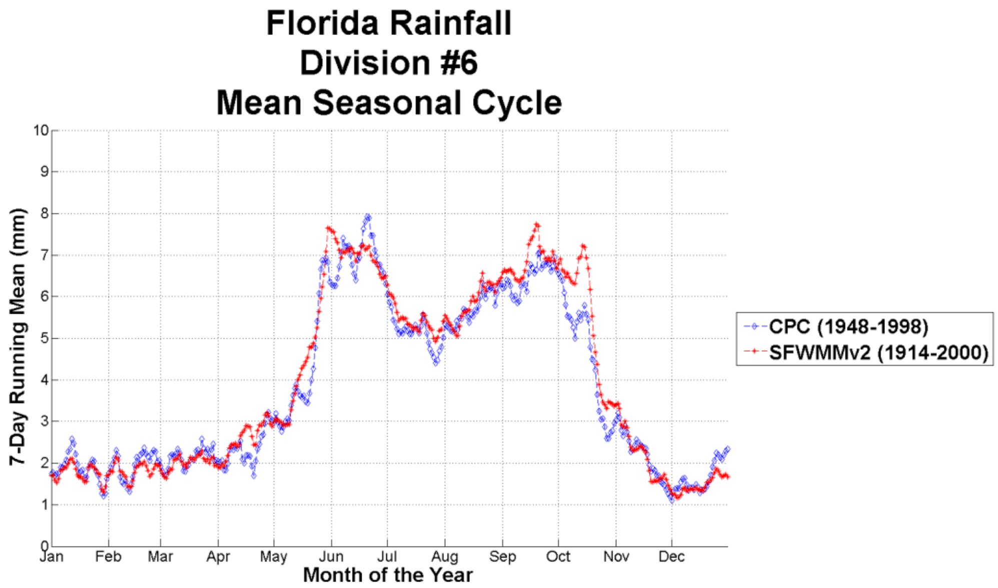
# Convective Rainfall in Florida and the Caribbean

Roque Vinicio Céspedes

**MPO 663 - Convective and Mesoscale Meteorology**

April 27, 2011

# The Caribbean’s Rainfall Cycle




According to Magaña et al. (1999), Ashby et al. (2005), and Stephenson et al. (2008), the summer rainfall season in most of the Caribbean follows a distinctly bimodal distribution pattern: increased rainfall from May through early July, a period of relatively drier weather in late July and early August called the midsummer drought (MSD), and increased rainfall again from late August through October. The start of the rainy season in the Caribbean is generally marked by the northward movement of the North Atlantic subtropical high (NASH). The NASH remains north throughout the summer rainy season from May through October, with a slight shift south and then back north during the MSD period (Ashby et al., 2005).

# Curtis and Gamble (2008)

## MSD Regional Temporal Variations

Regional variations of the Caribbean mid-summer drought

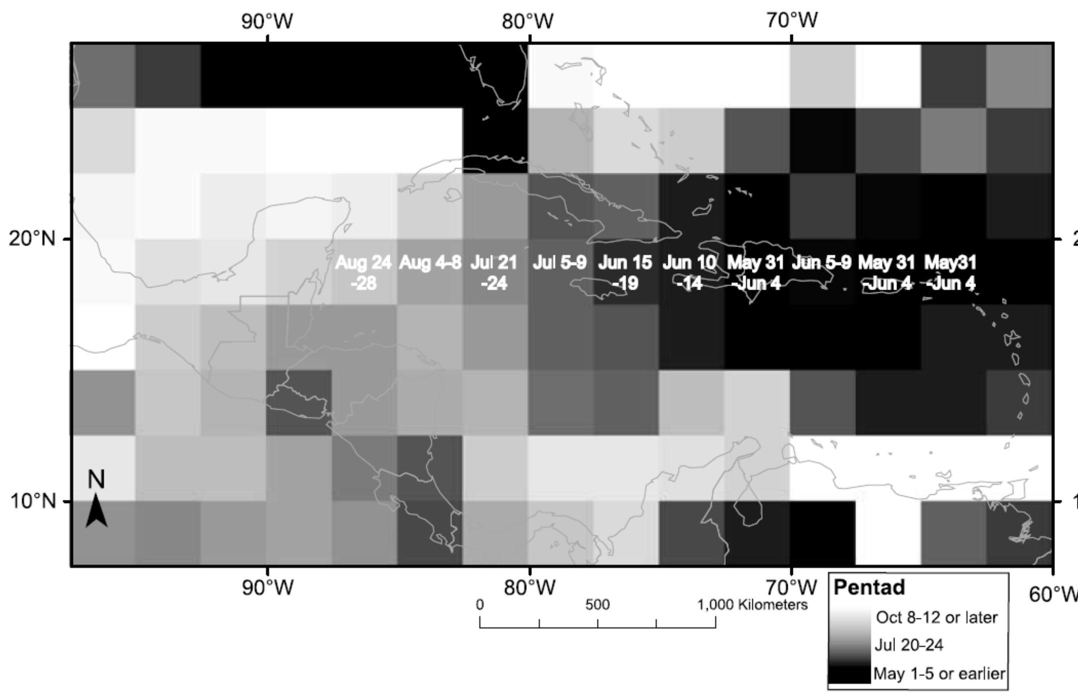



**Fig. 4.** Pentad of the maximum power displayed in Fig. 3. Blocks labeled along the 18.75° N parallel illustrate the progression of the MSD from east to west

# Curtis and Gamble (2008)

## MSD Regional Variations in Duration + Intensity

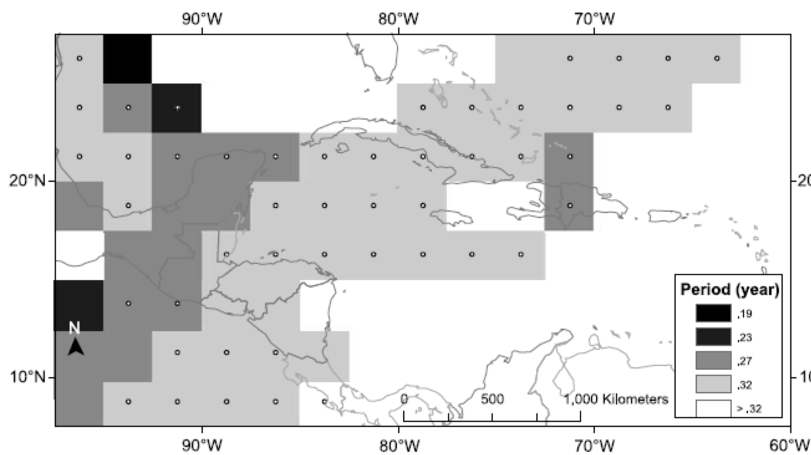



**Fig. 2.** Period (year) of maximum power in the wavelet spectrum between 0.164 (60 days) and 0.328 years (120 days). Circles denote 99% significant values determined by "time-average" test

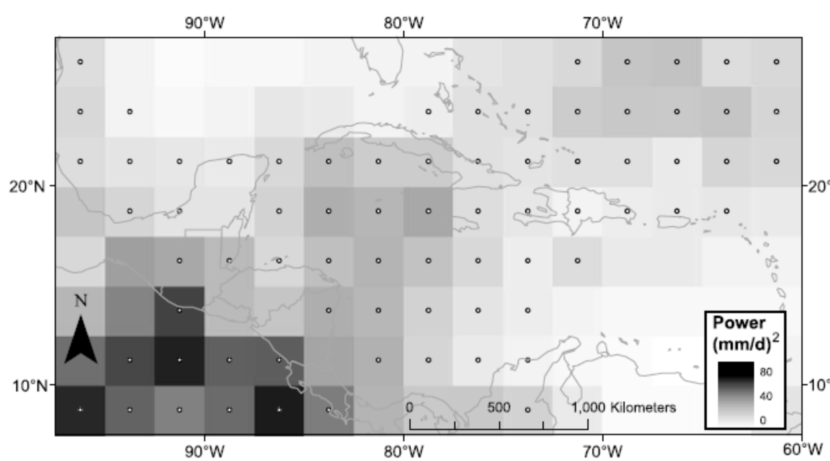



**Fig. 3.** Maximum power (mm $day^{-1})^2$ at the 0.320-year (117 day) period of the wavelet spectrum. Circles denote 99% significant values determined by "time-average" test

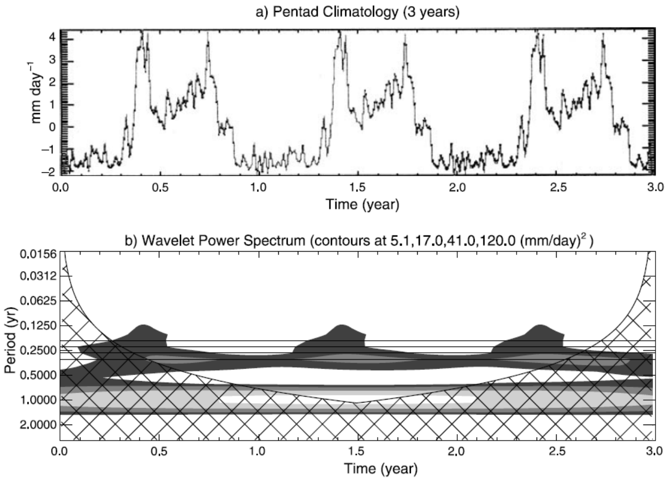



**Fig. 1.** Wavelet analysis of climatological GPCP pentad precipitation for the grid block centered at 78.75° W and 18.75° N. (**a**) annual precipitation anomaly time series repeated three times; (**b**) wavelet power spectrum. Contours of 5.1 (mm day$^{-1}$)$^2$, 17.0 (mm day$^{-1}$)$^2$, 41.0 (mm day$^{-1}$)$^2$, and 120.0 (mm day$^{-1}$)$^2$ are filled as dark grey, medium grey, light grey, and white, respectively. Horizontal lines denote 4 resolved MSD periods. Cross-hatched regions indicate the "cone of influence" where edge effects degrade the analysis

# Curtis and Gamble (2008)

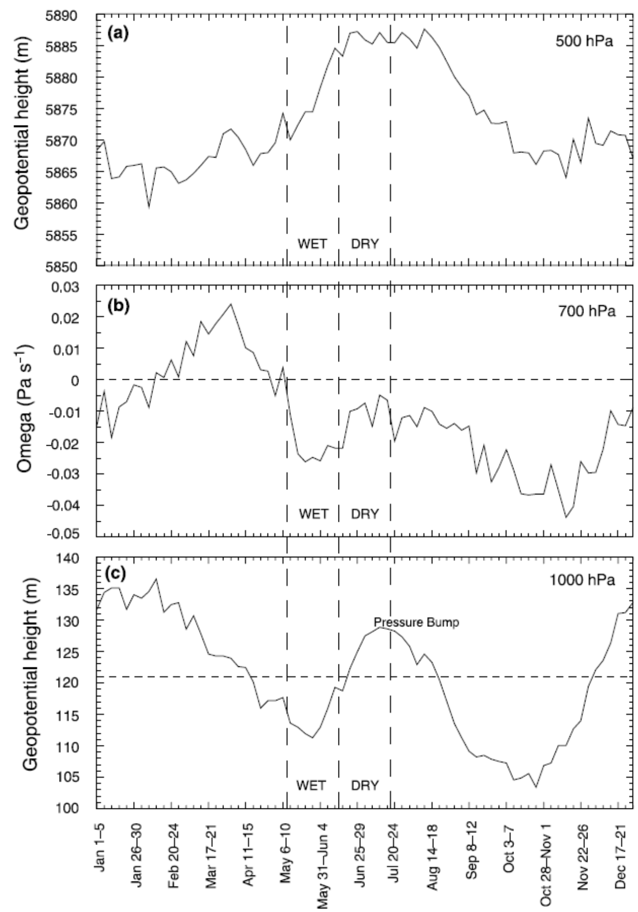



**Fig. 5.** Climatological NCEP/NCAR reanalysis data for the grid block centered at 80° W and 17.5° N. Early wet season and mid-summer dry season for that location are denoted. (**a**) Geopotential height (m) at 500 hPa, (**b**) vertical velocity in pressure coordinates (omega; Pa s$^{-1}$) at 700 hPa. Horizontal line marks zero. (**c**) Geopotential height (m) at 1000 hPa. Horizontal line is the annual average. Pressure bump discussed in the text is labeled

# Curtis and Gamble (2008)

## “Bump” in SLP - Regional Temporal Variations

Regional variations of the Caribbean mid-summer drought

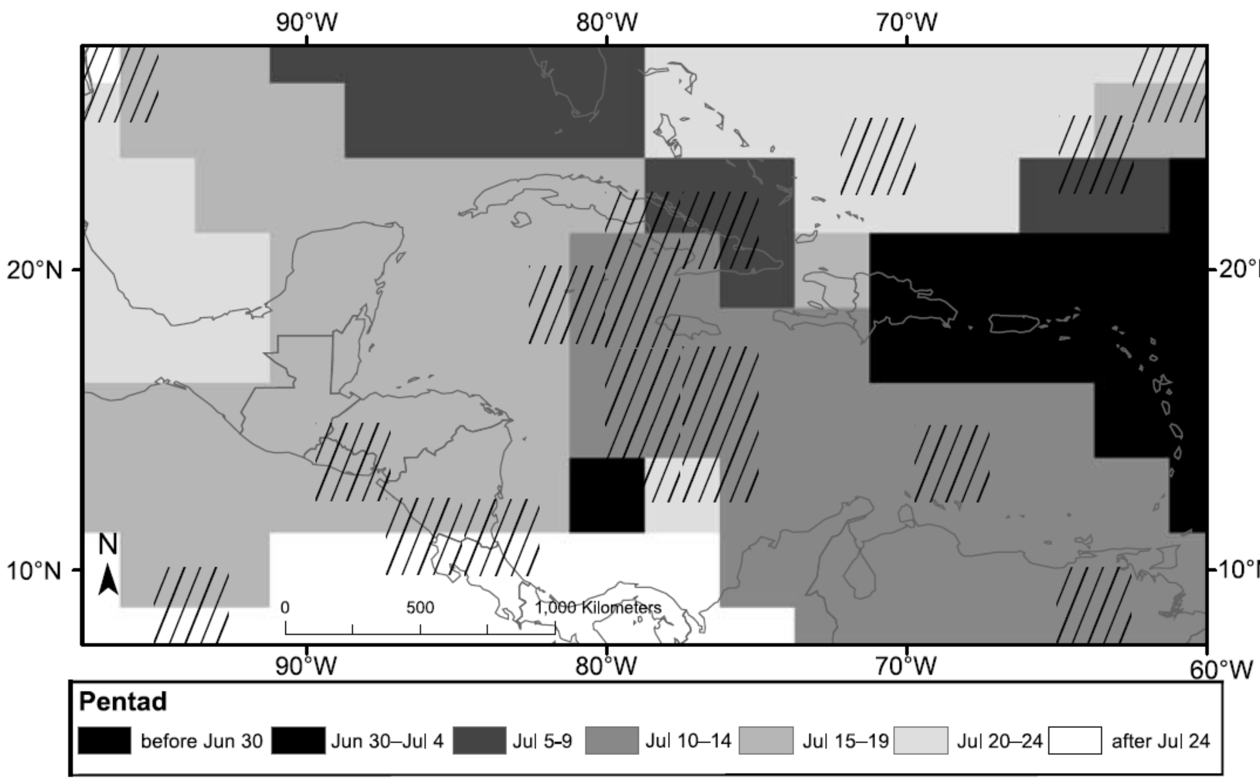
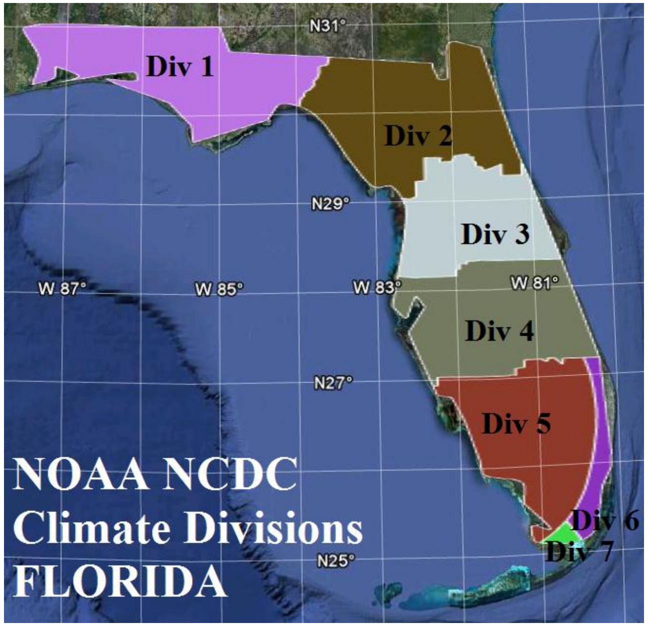
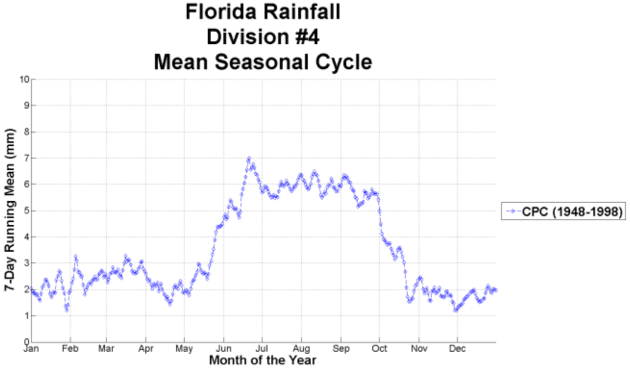
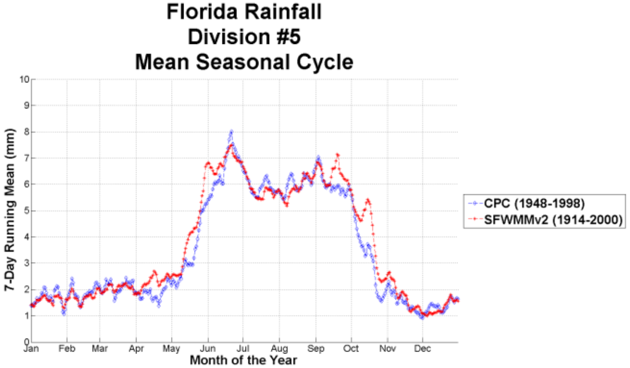


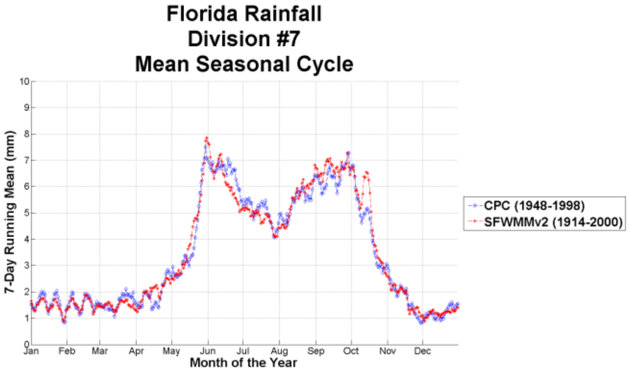

**Fig. 6.** Pentad of maximum climatological NCEP/NCAR 1000 hPa geopotential height between May 1–5 and October 8–12. Cross hatched areas show GPCP precipitation grid blocks where the pentad of maximum power (Fig. 4) occurred between June 30 and July 24

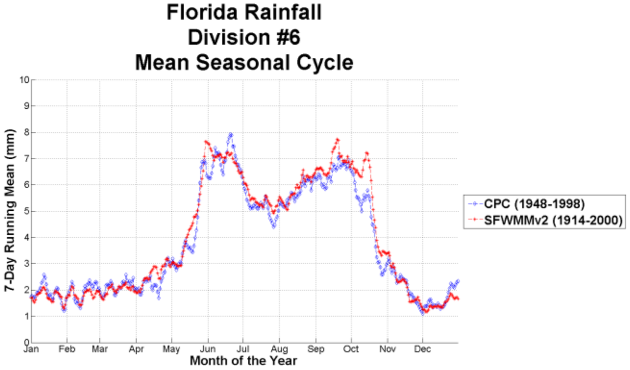
# Florida's Mean Rainfall Cycle, Part 1



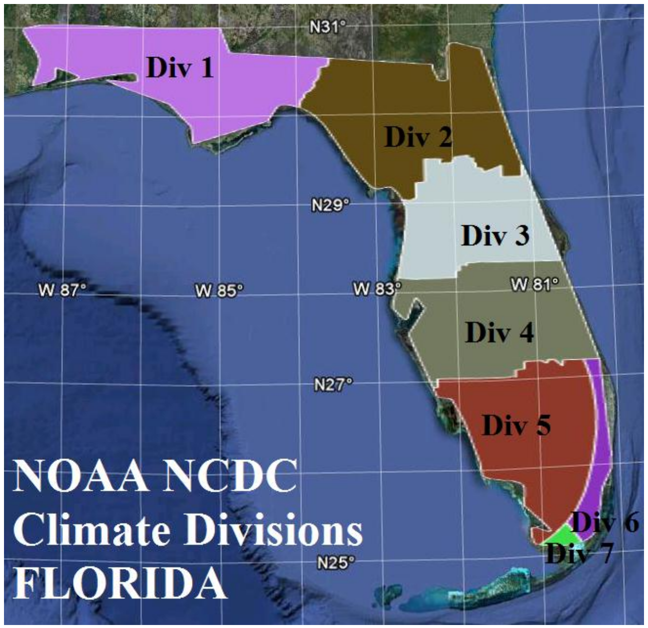



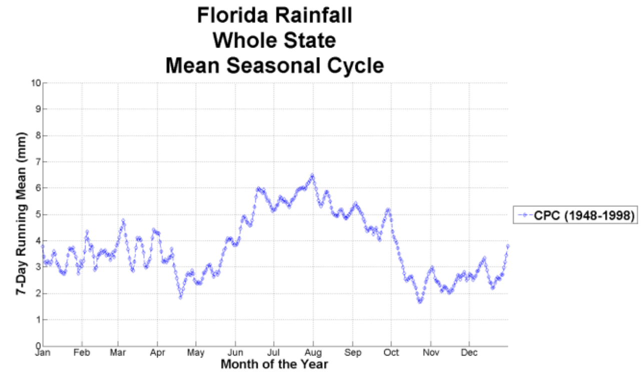



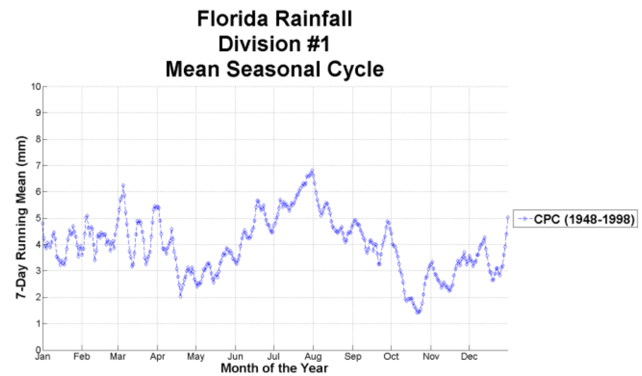



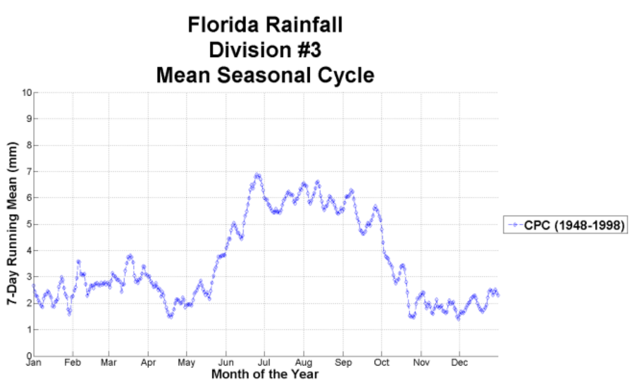



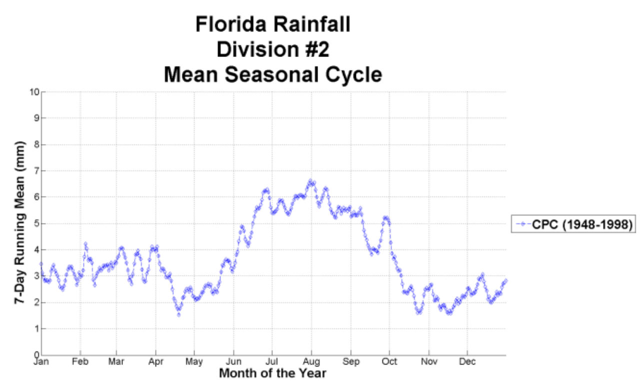
# Florida’s Mean Rainfall Cycle, Part 2



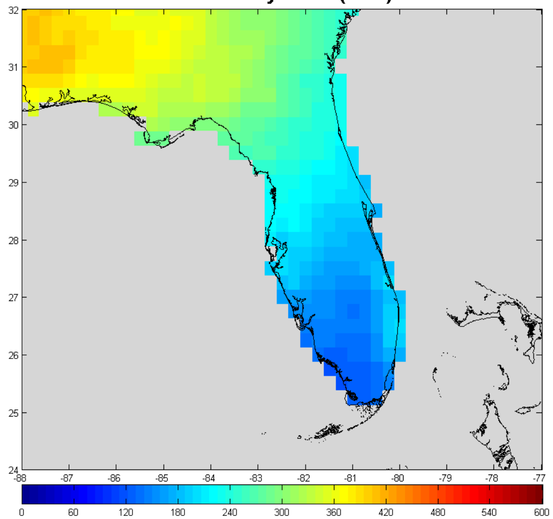



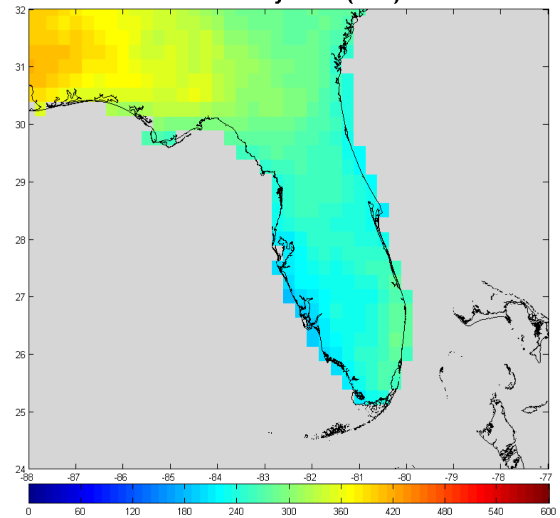



# Florida’s Mean Rainfall Cycle, Part 3

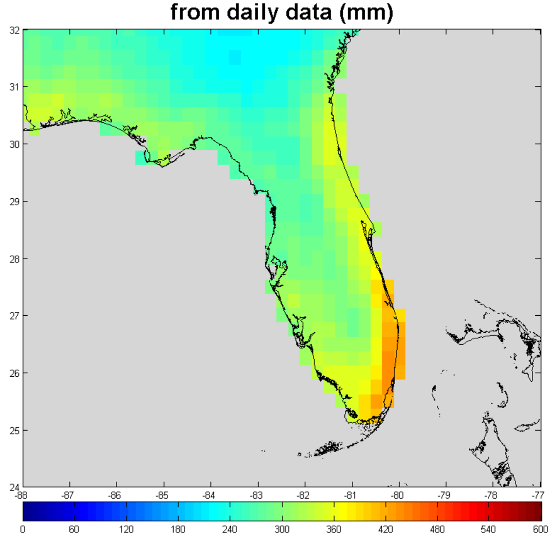
NOAA CPC 0.25° x 0.25°
Mean 1948-1998 DJF Accum. Precip.
from daily data (mm)



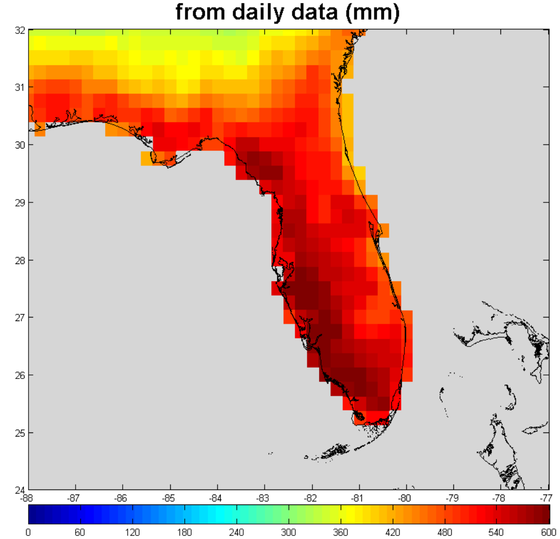

NOAA CPC 0.25° x 0.25°
Mean 1948-1998 MAM Accum. Precip.
from daily data (mm)




NOAA CPC 0.25° x 0.25°
Mean 1948-1998 SON Accum. Precip.
from daily data (mm)

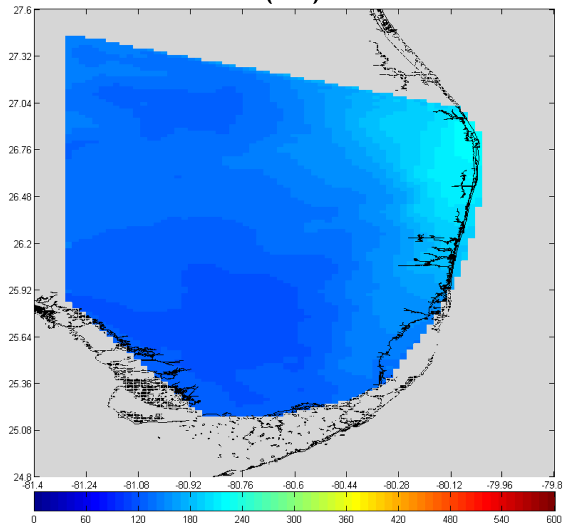



NOAA CPC 0.25° x 0.25°
Mean 1948-1998 JJA Accum. Precip.
from daily data (mm)

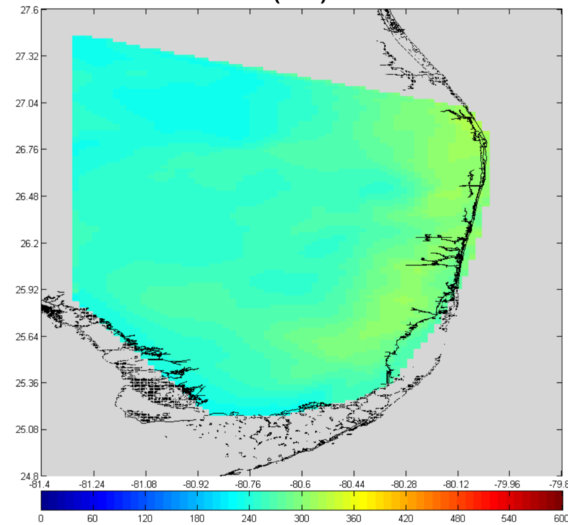


# Florida’s Mean Rainfall Cycle, Part 4

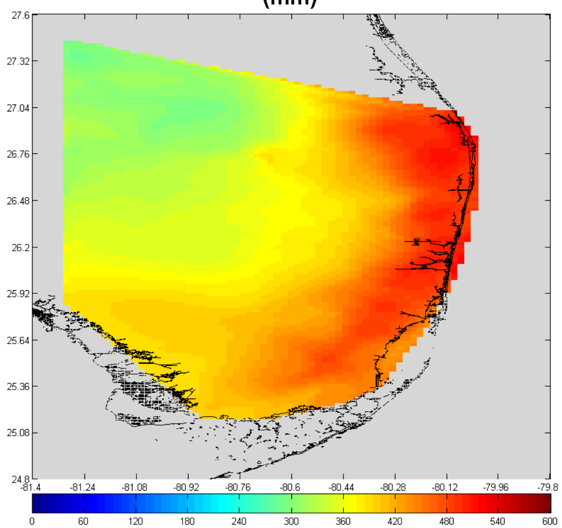
**SFWMM**
**Mean 1914-2000 DJF Accum. Precip.**
**(mm)**



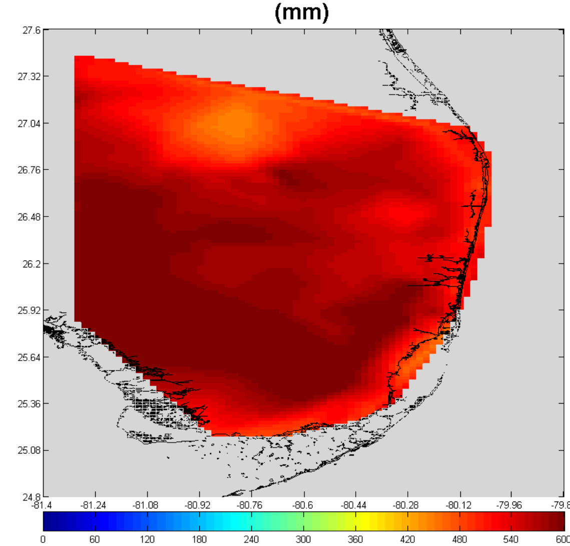

**SFWMM**
**Mean 1914-2000 MAM Accum. Precip.**
**(mm)**




**SFWMM**
**Mean 1914-2000 SON Accum. Precip.**
**(mm)**




**SFWMM**
**Mean 1914-2000 JJA Accum. Precip.**
**(mm)**



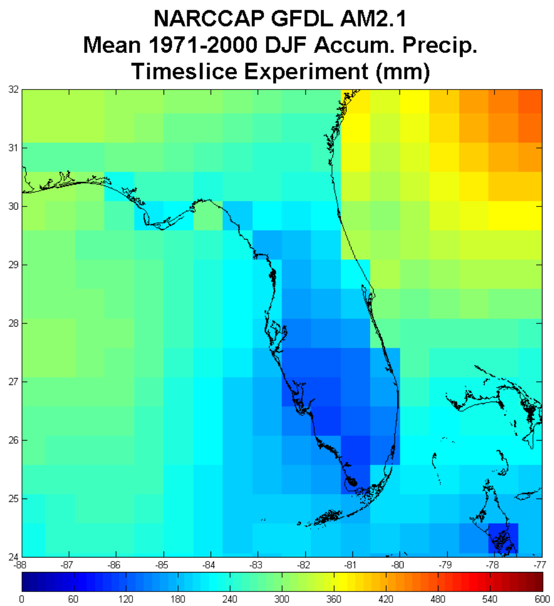
# NARCCAP GFDL AM2.1 Timeslice Experiment

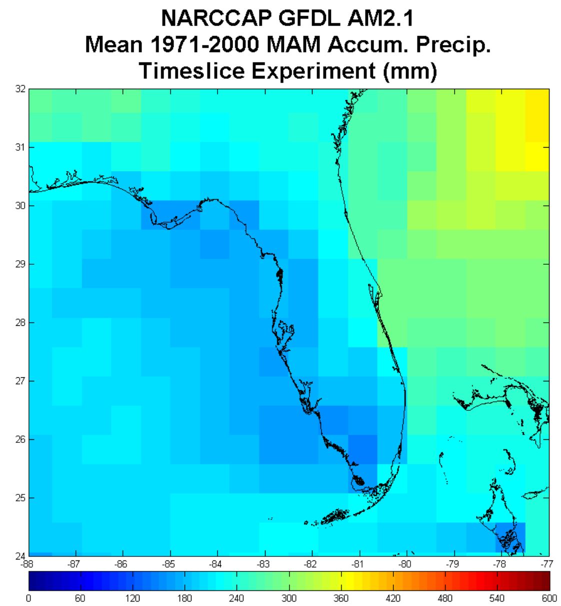
- Resolution: 0.5$^{o}$ lat by 0.625$^{o}$ lon
- Model domain: Global
- Scenario: IPCC A-2

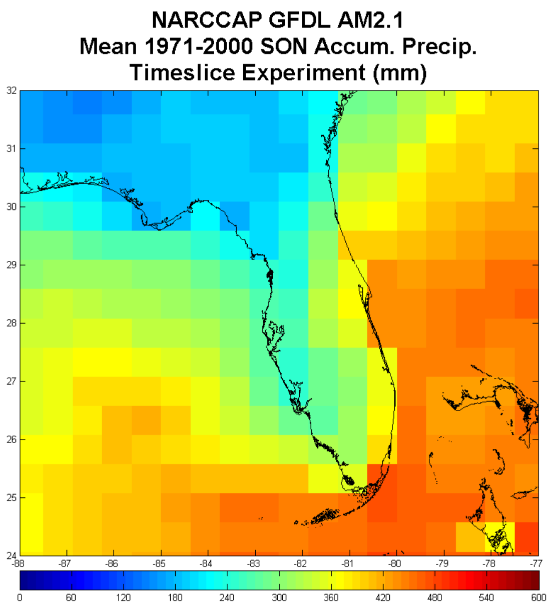
  "A very heterogeneous world…"

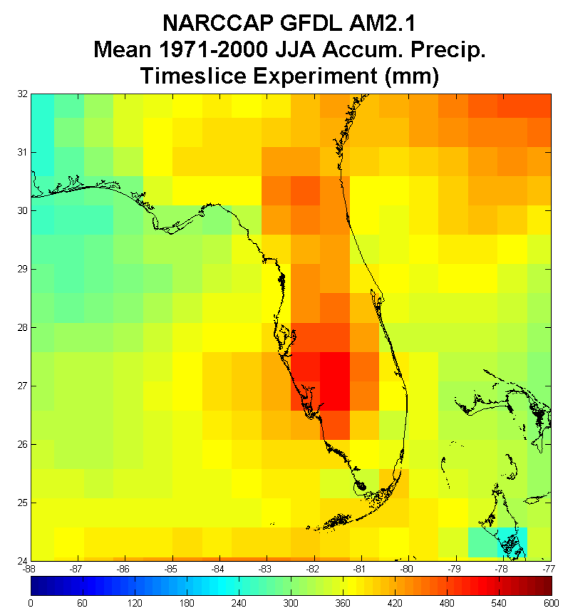
  A.K.A., "Business as usual emissions"
- Time periods: 1968–2000, 2038–2070

# NARCCAP GFDL AM2.1 Timeslice Experiment



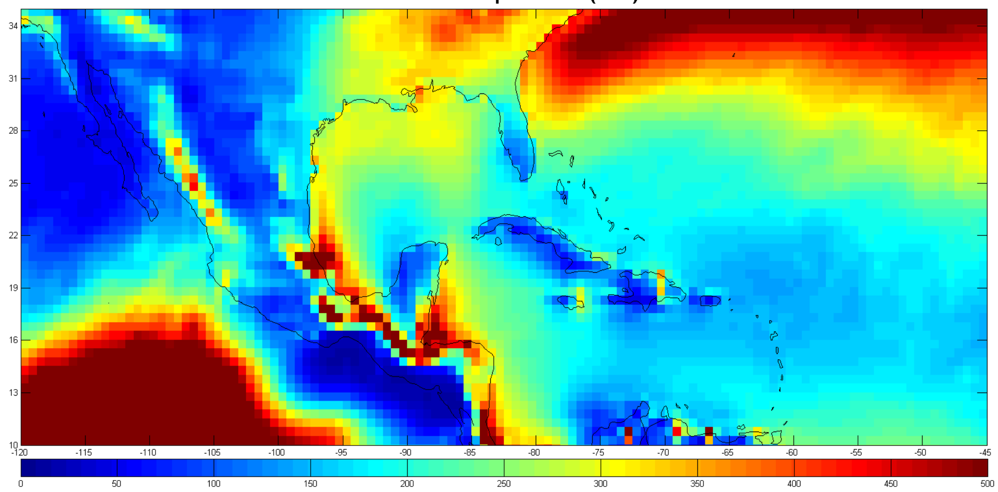



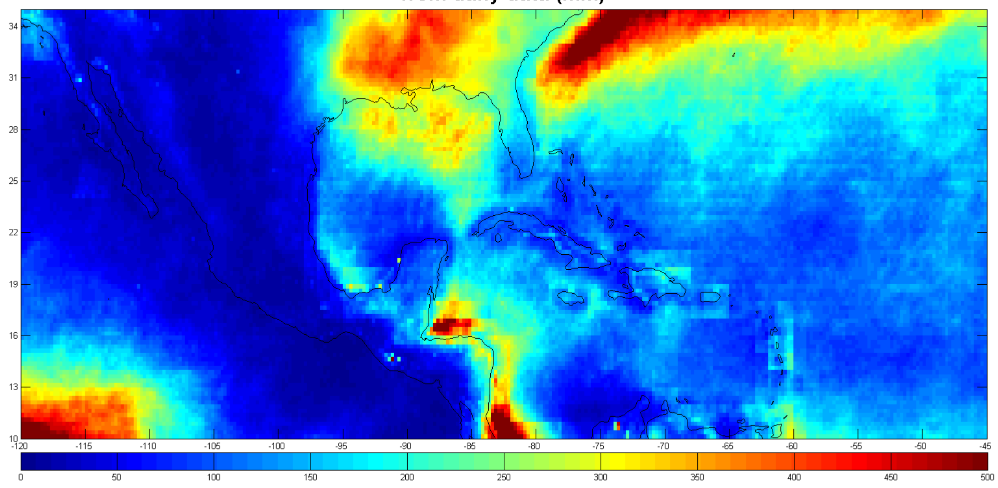



# NARCCAP GFDL AM2.1 Timeslice Experiment

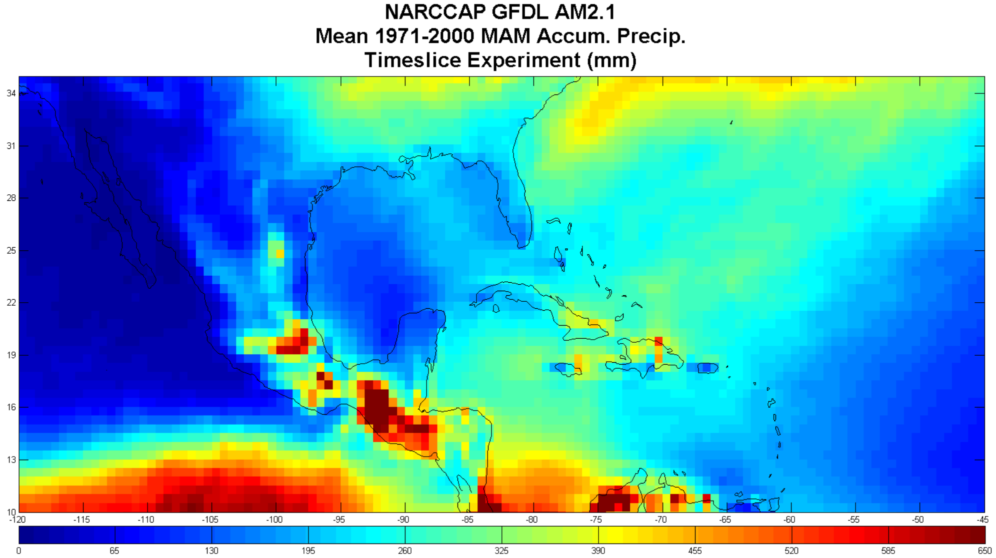
NARCCAP GFDL AM2.1
Mean 1971-2000 DJF Accum. Precip.
Timeslice Experiment (mm)

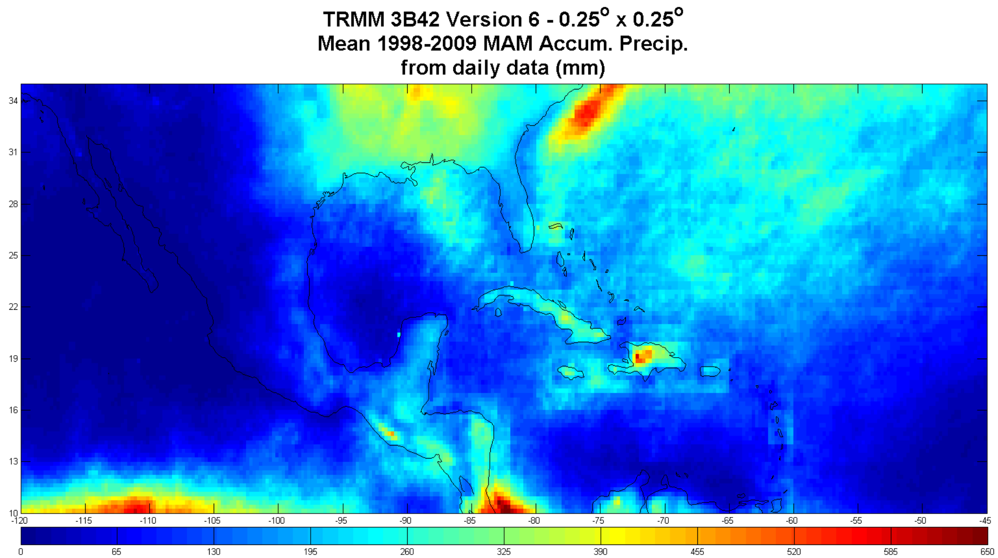


TRMM 3B42 Version 6 - 0.25° x 0.25°
Mean 1998-2009 DJF Accum. Precip.
from daily data (mm)



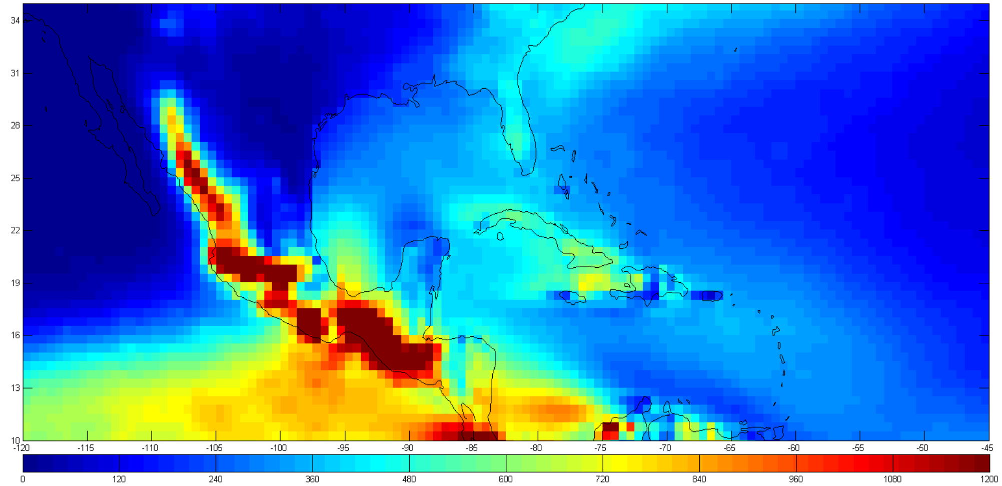
# NARCCAP GFDL AM2.1 Timeslice Experiment



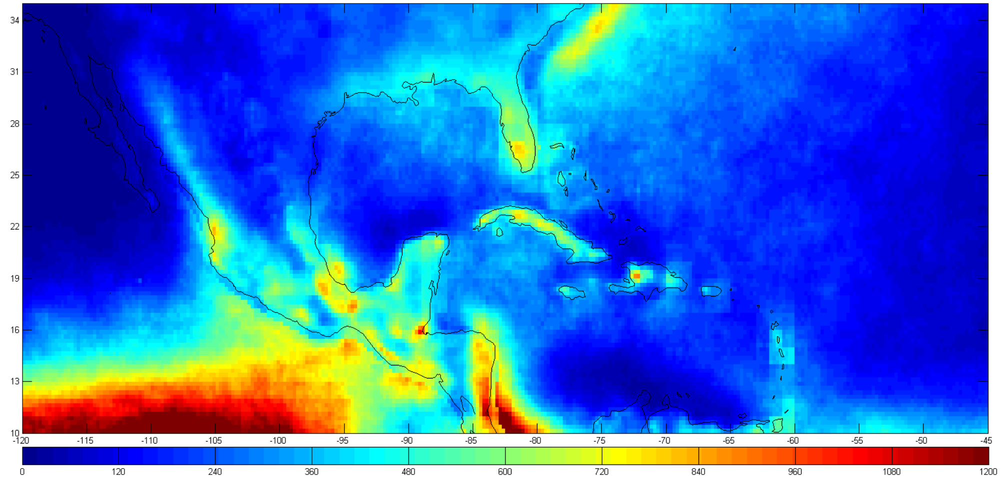



# NARCCAP GFDL AM2.1 Timeslice Experiment

NARCCAP GFDL AM2.1
Mean 1971-2000 JJA Accum. Precip.
Timeslice Experiment (mm)

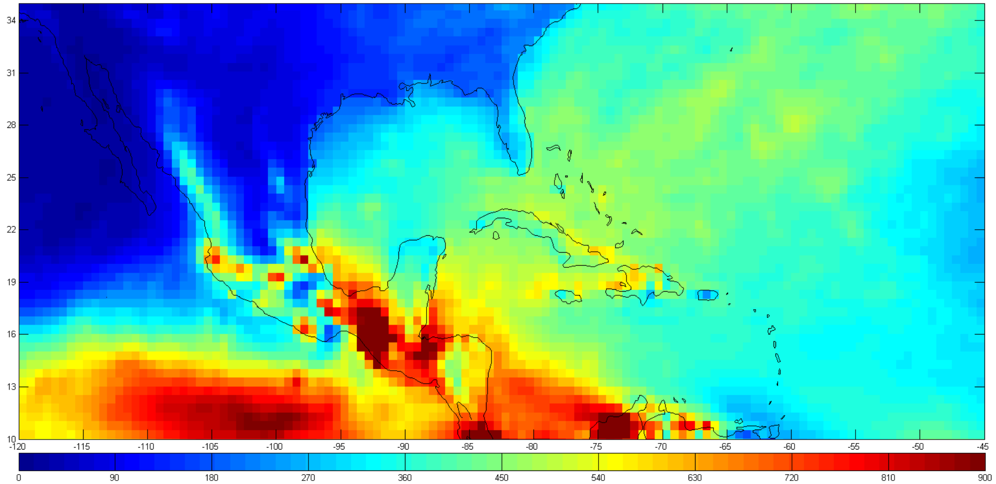



TRMM 3B42 Version 6 - 0.25° x 0.25°
Mean 1998-2009 JJA Accum. Precip.
from daily data (mm)

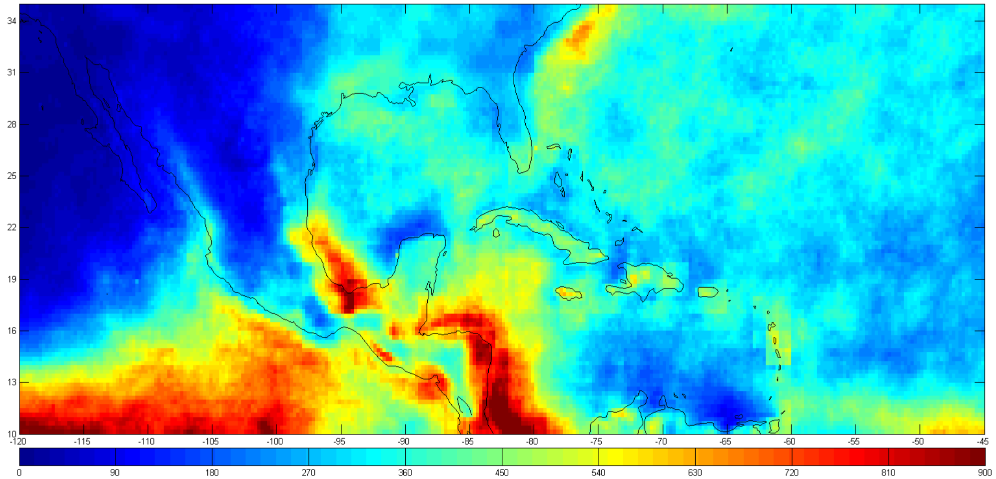


# NARCCAP GFDL AM2.1 Timeslice Experiment

NARCCAP GFDL AM2.1
Mean 1971-2000 SON Accum. Precip.
Timeslice Experiment (mm)

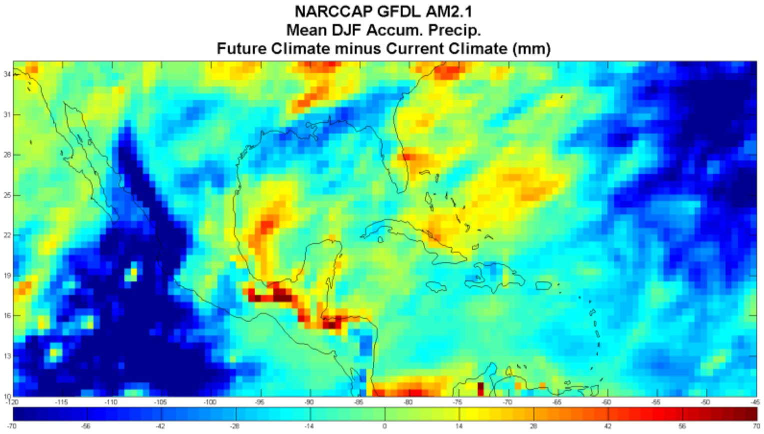


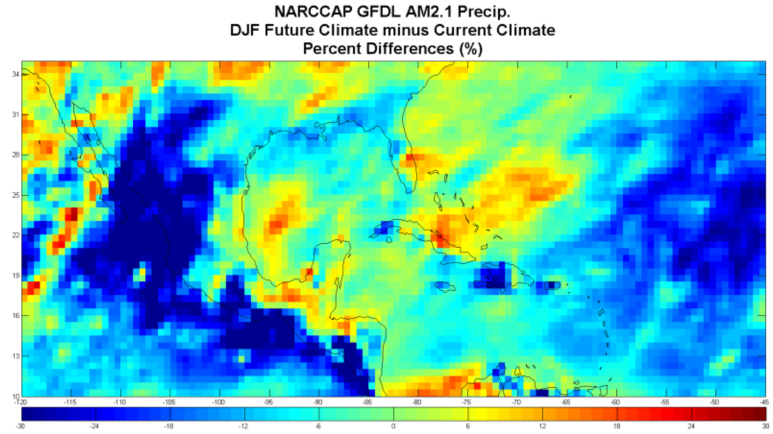

TRMM 3B42 Version 6 - 0.25° x 0.25°
Mean 1998-2009 SON Accum. Precip.
from daily data (mm)

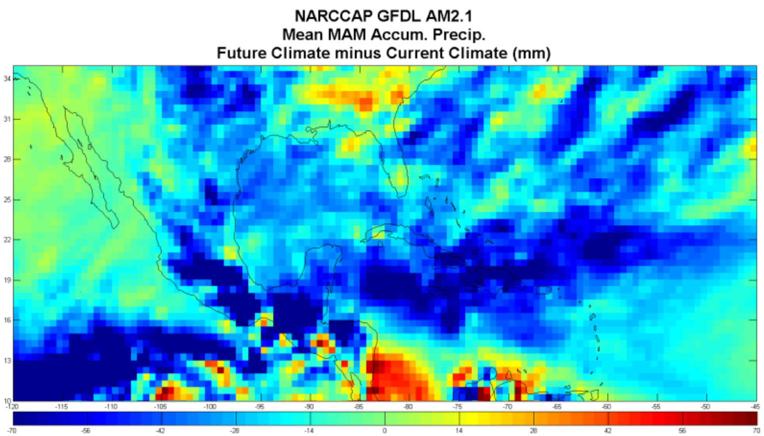


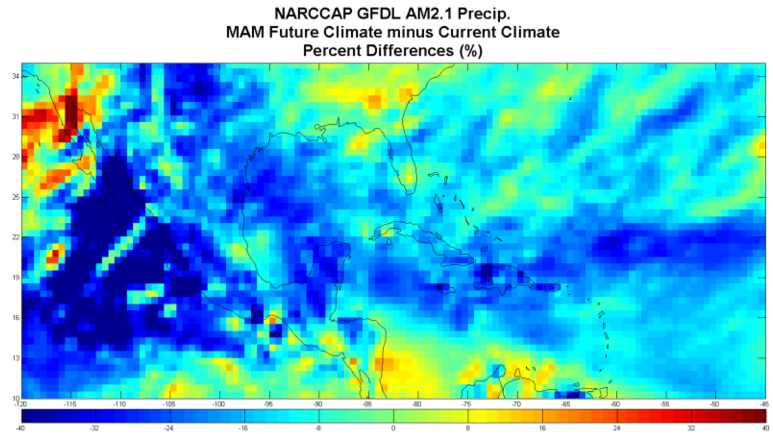
# NARCCAP GFDL AM2.1 Timeslice Experiment

# Projections



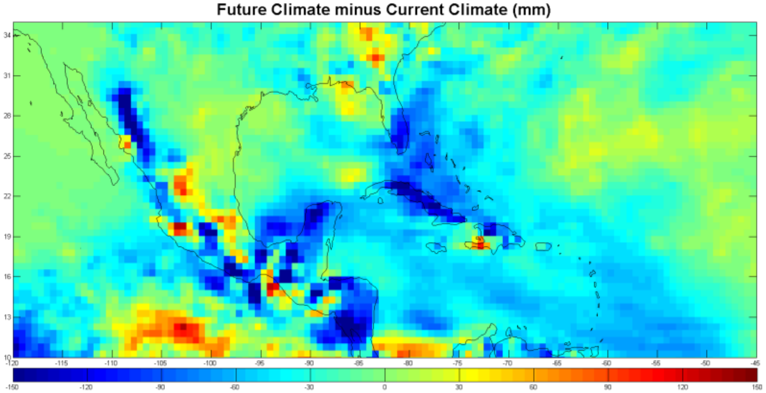



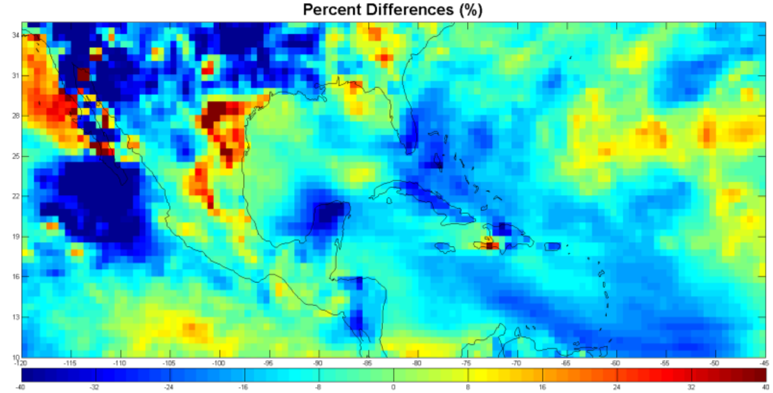
# NARCCAP GFDL AM2.1 Timeslice Experiment

## Projections

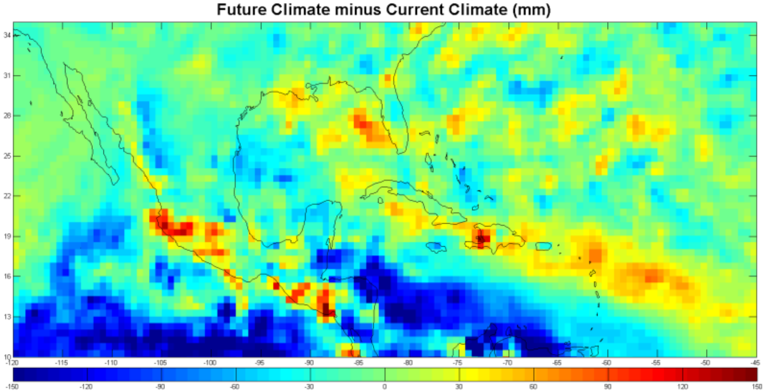
NARCCAP GFDL AM2.1
Mean JJA Accum. Precip.
Future Climate minus Current Climate (mm)



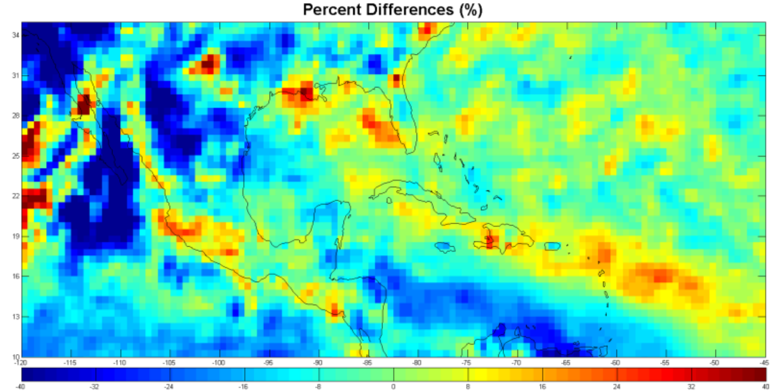
NARCCAP GFDL AM2.1 Precip.
JJA Future Climate minus Current Climate
Percent Differences (%)



NARCCAP GFDL AM2.1
Mean SON Accum. Precip.
Future Climate minus Current Climate (mm)



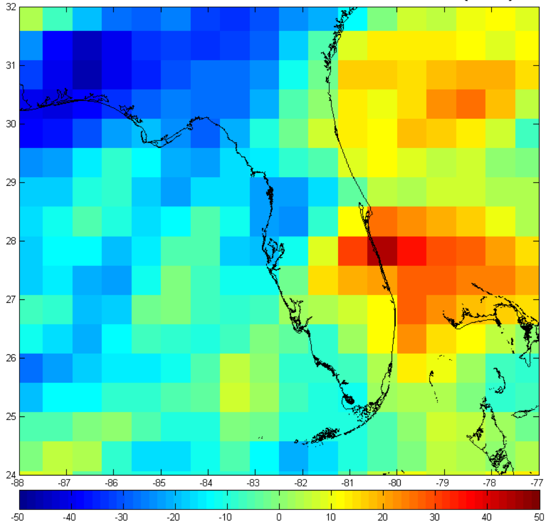
NARCCAP GFDL AM2.1 Precip.
SON Future Climate minus Current Climate
Percent Differences (%)



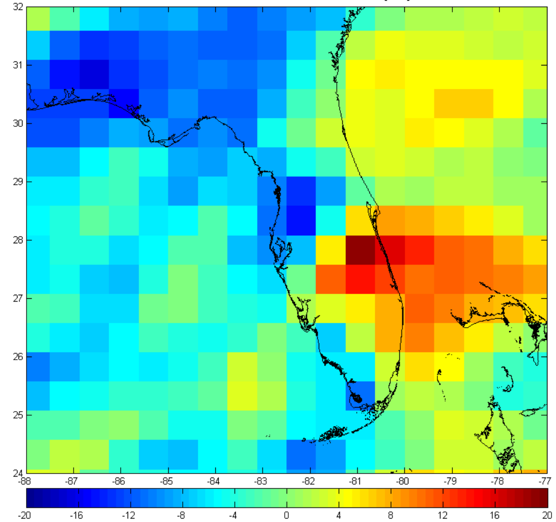
# NARCCAP GFDL AM2.1 Timeslice Experiment

# Projections

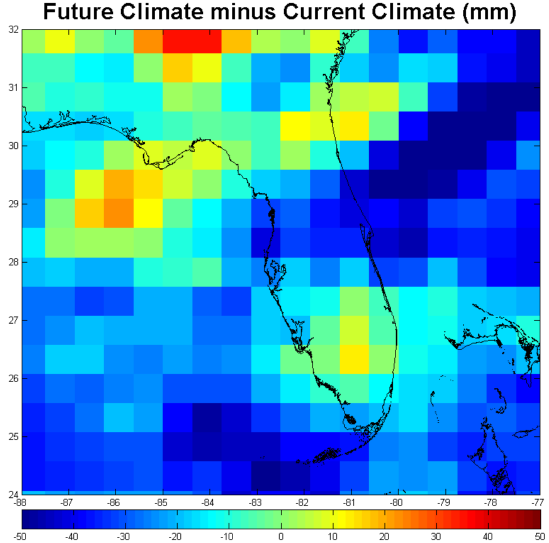
NARCCAP GFDL AM2.1
Mean DJF Accum. Precip.
Future Climate minus Current Climate (mm)



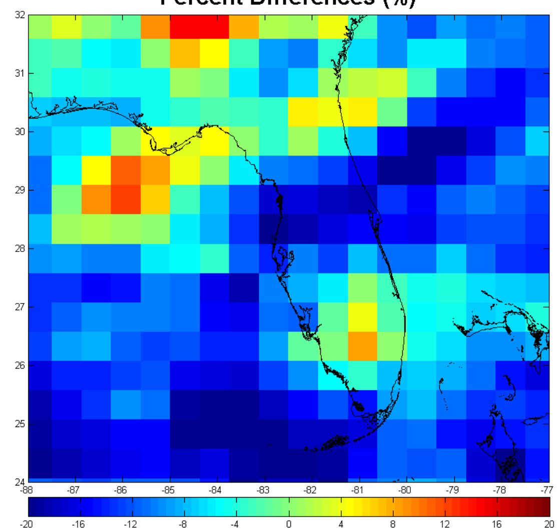

NARCCAP GFDL AM2.1 Precip.
DJF Future Climate minus Current Climate
Percent Differences (%)




NARCCAP GFDL AM2.1
Mean MAM Accum. Precip.
Future Climate minus Current Climate (mm)



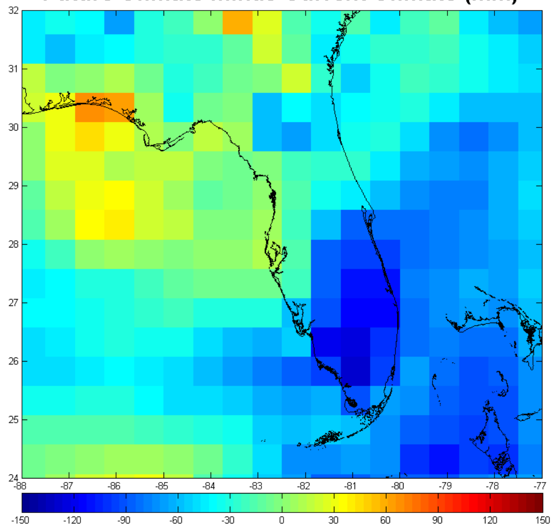

NARCCAP GFDL AM2.1 Precip.
MAM Future Climate minus Current Climate
Percent Differences (%)



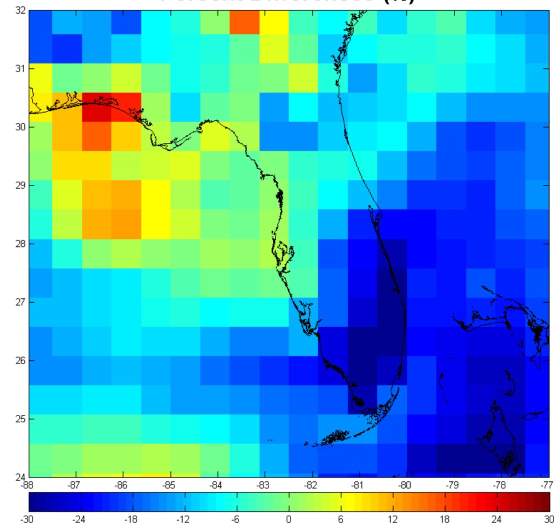
# NARCCAP GFDL AM2.1 Timeslice Experiment

## Projections

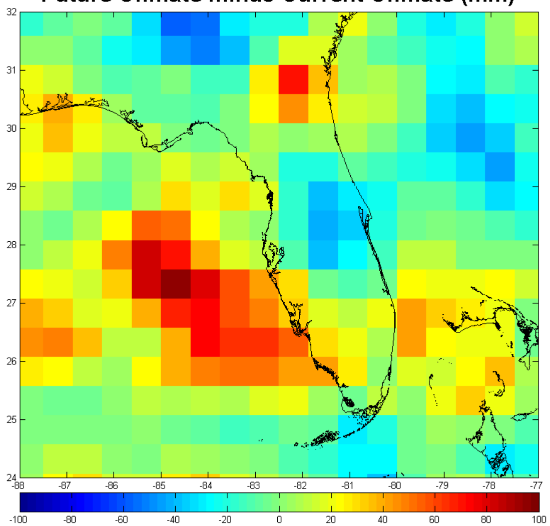
NARCCAP GFDL AM2.1
Mean JJA Accum. Precip.
Future Climate minus Current Climate (mm)



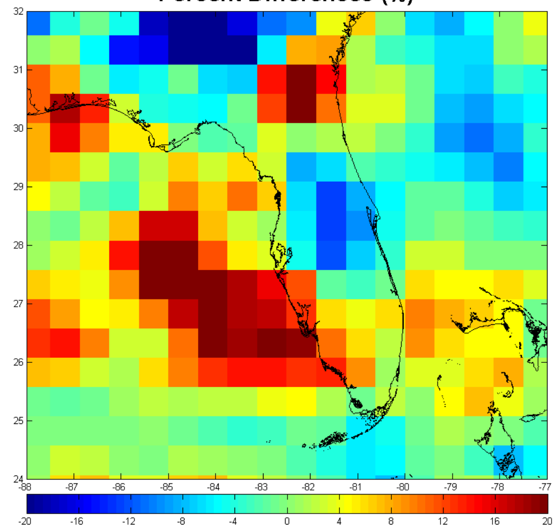

NARCCAP GFDL AM2.1 Precip.
JJA Future Climate minus Current Climate
Percent Differences (%)



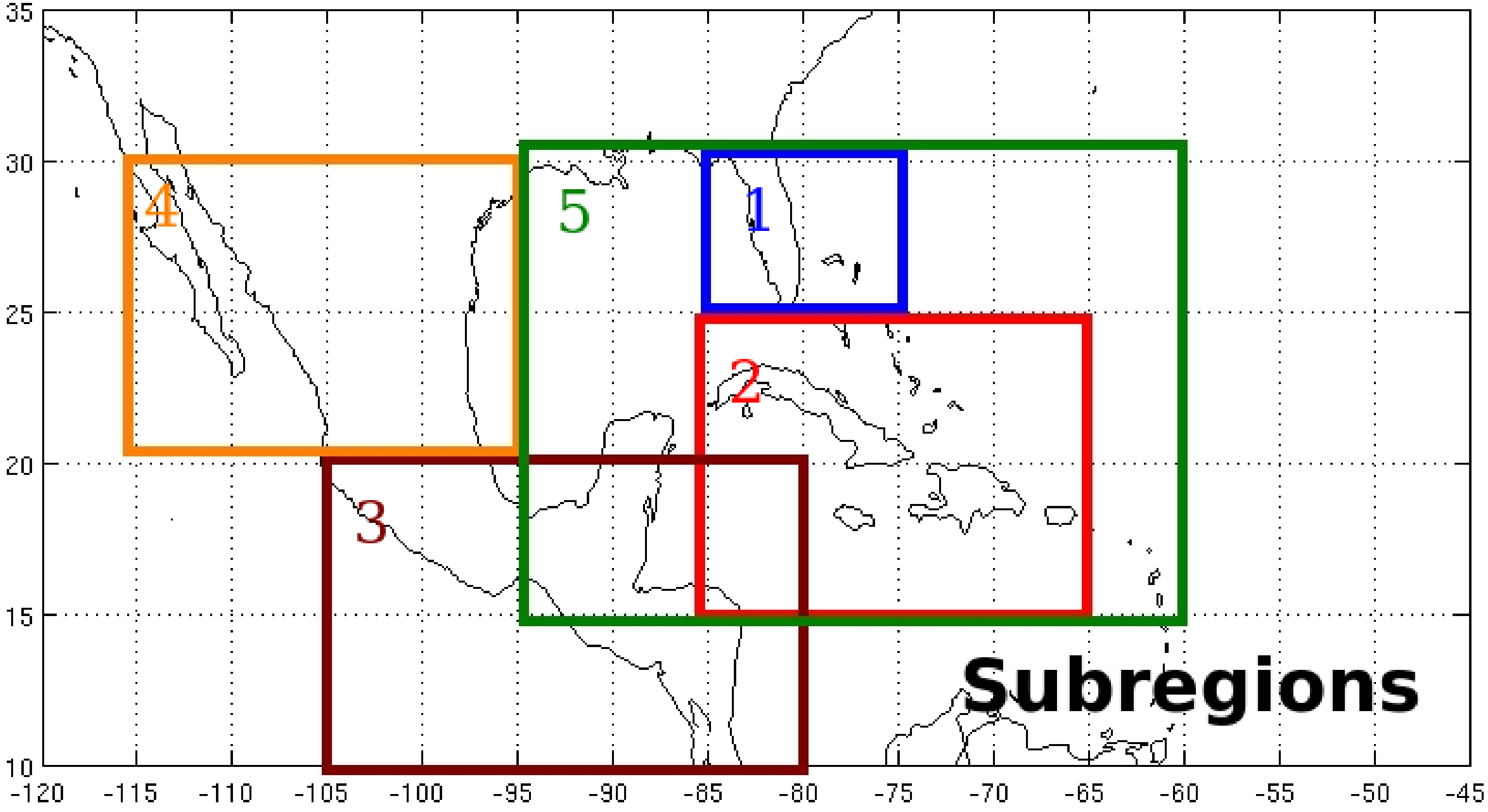

NARCCAP GFDL AM2.1
Mean SON Accum. Precip.
Future Climate minus Current Climate (mm)



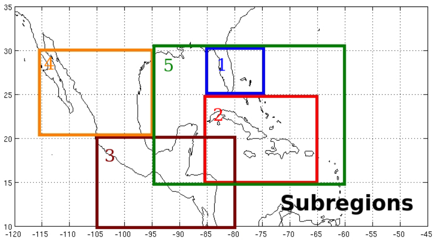

NARCCAP GFDL AM2.1 Precip.
SON Future Climate minus Current Climate
Percent Differences (%)



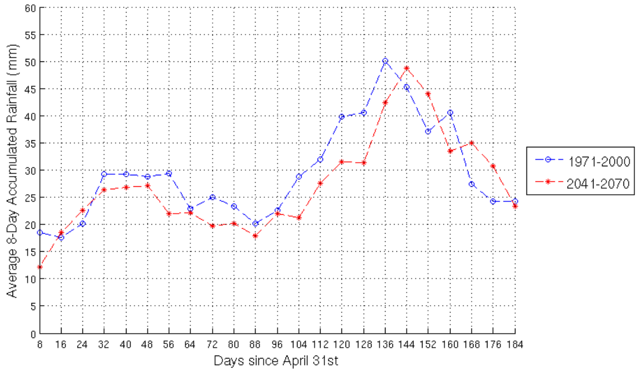
# Céspedes et al. (2009)



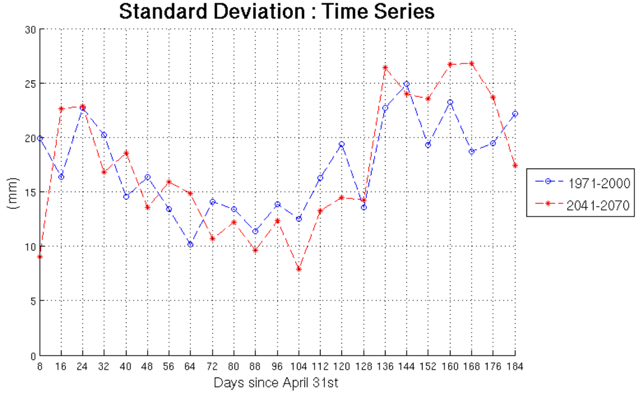
# Céspedes et al. (2009)



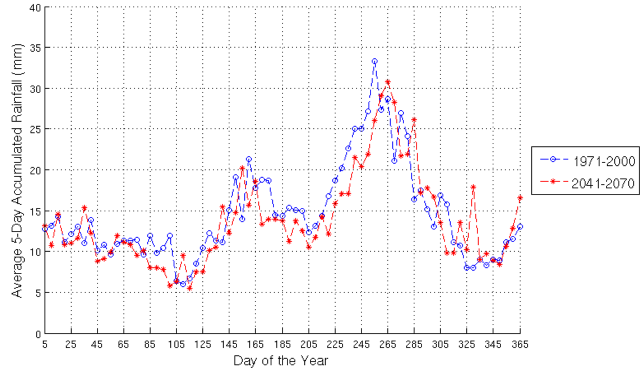

GFDL AM2.1 Simulations - Florida Region
Average May 1st - Oct. 31st Rainfall
Time Series



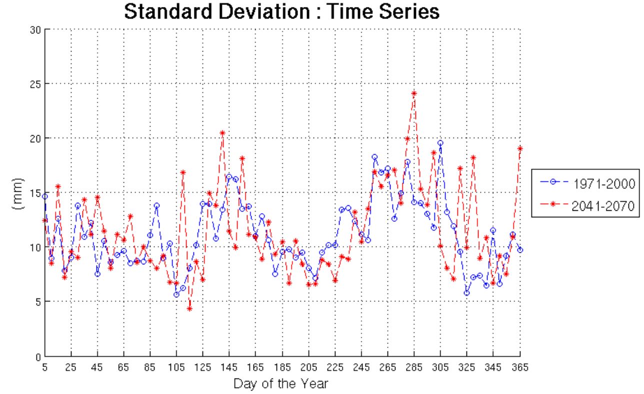

GFDL AM2.1 Simulations - Florida Region
May 1st - Oct. 31st 8-Day Accumulated Rainfall
Standard Deviation : Time Series



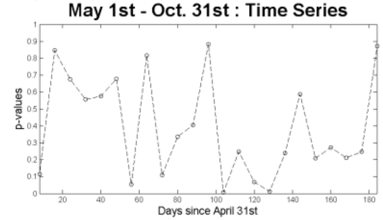

GFDL AM2.1 Simulations - Florida Region
Average Jan. 1st - Dec. 31st Rainfall
Time Series



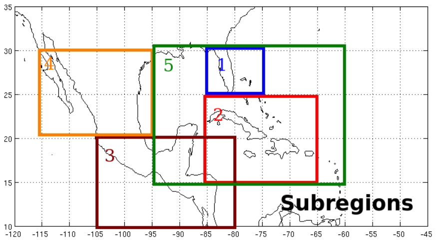

GFDL AM2.1 Simulations - Florida Region
Jan. 1st - Dec. 31st 5-Day Accumulated Rainfall
Standard Deviation : Time Series

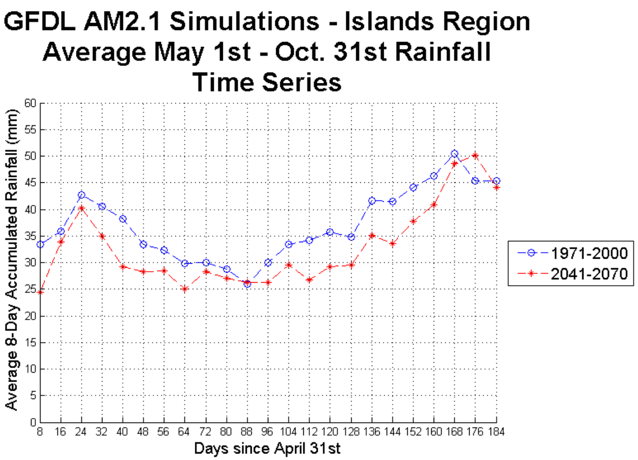


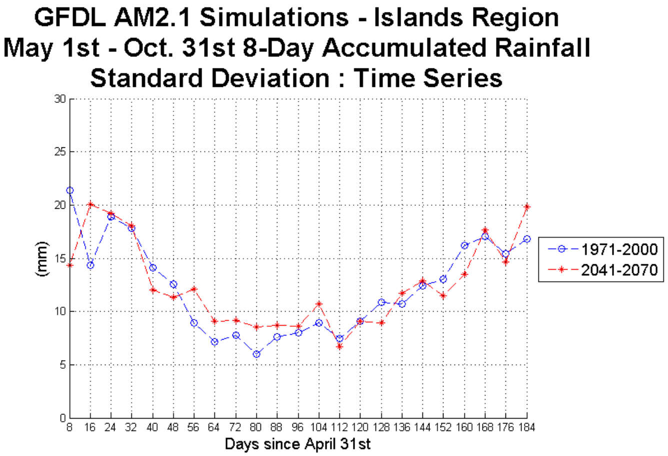

GFDL AM2.1 Simulations - Florida t-test
Regionally-Averaged 8-Day Accumulated Rain
May 1st - Oct. 31st : Time Series

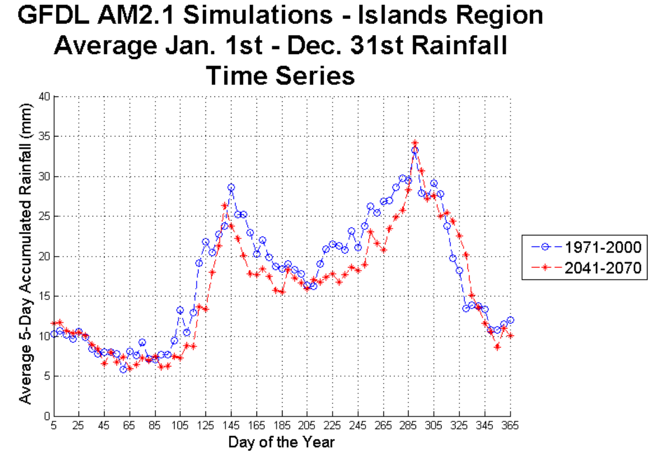


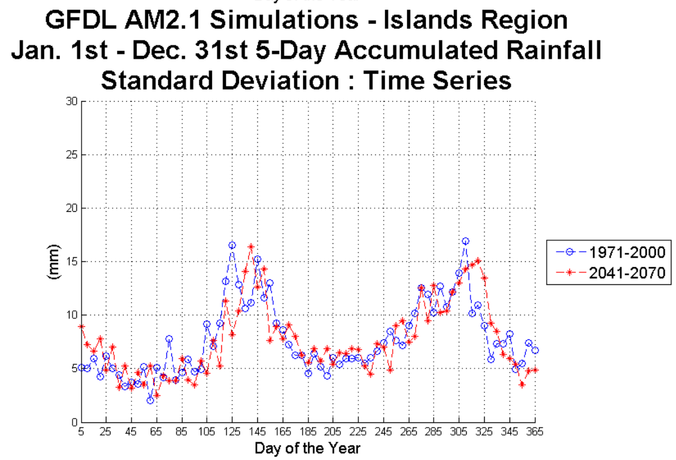
# The "Greater Antilles" Islands

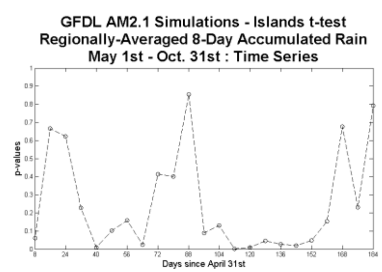


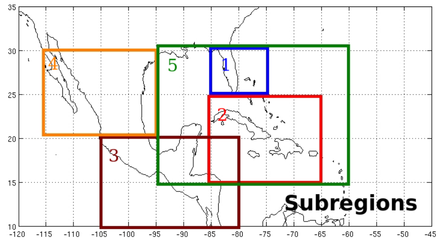



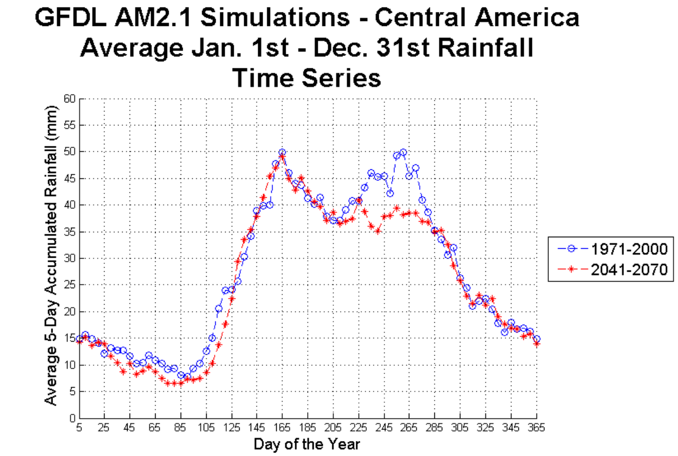



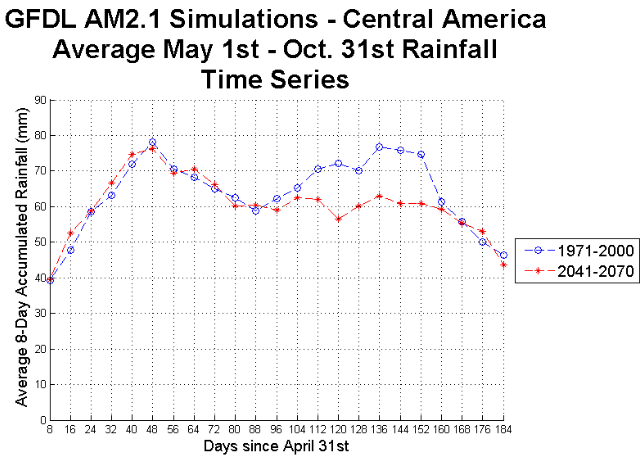



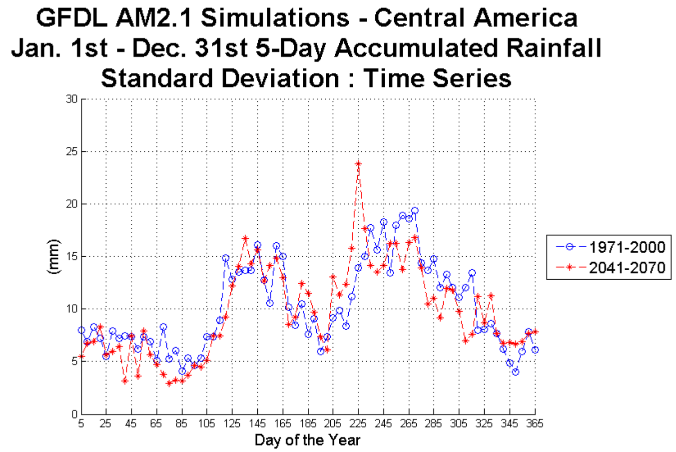



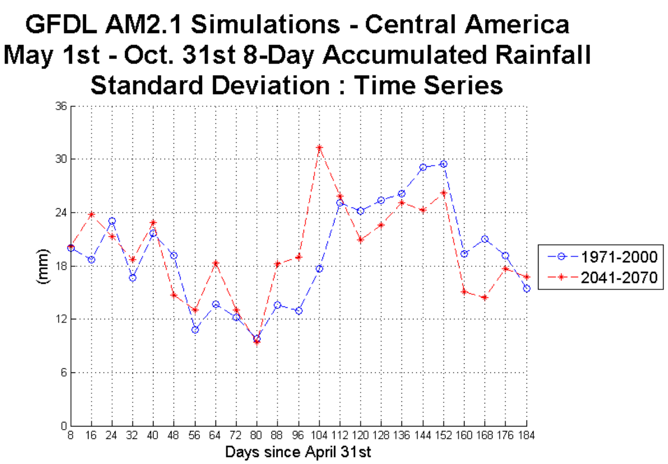
# Central America

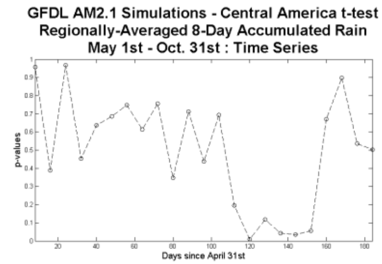


# Blanchard and López (1985)

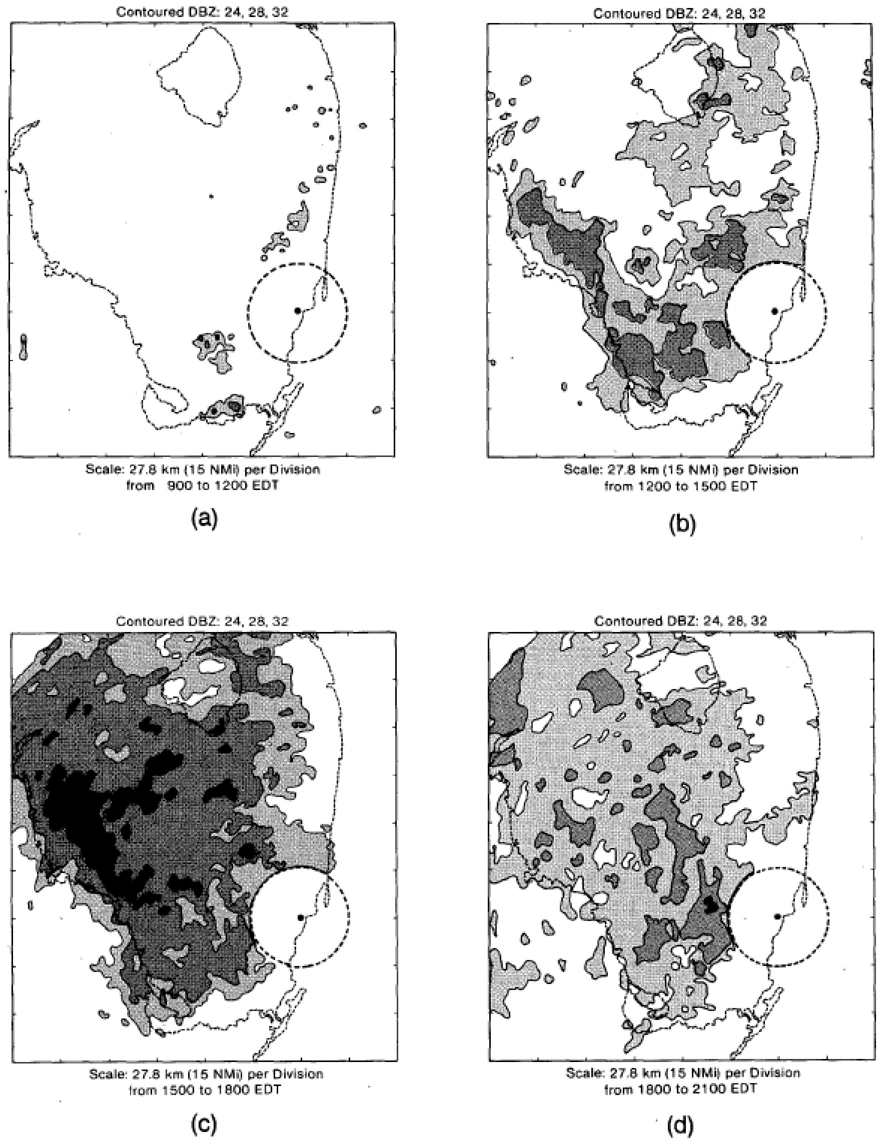



FIG. 2. Convective patterns over south Florida for Type 1 days for (a) 0900–1200, (b) 1200–1500, (c) 1500–1800 and (d) 1800–2100 EDT. Light shading is for radar reflectivities of 24 dBZ, medium shading is for 28 dBZ, and heavy shading is for 32 dBZ.

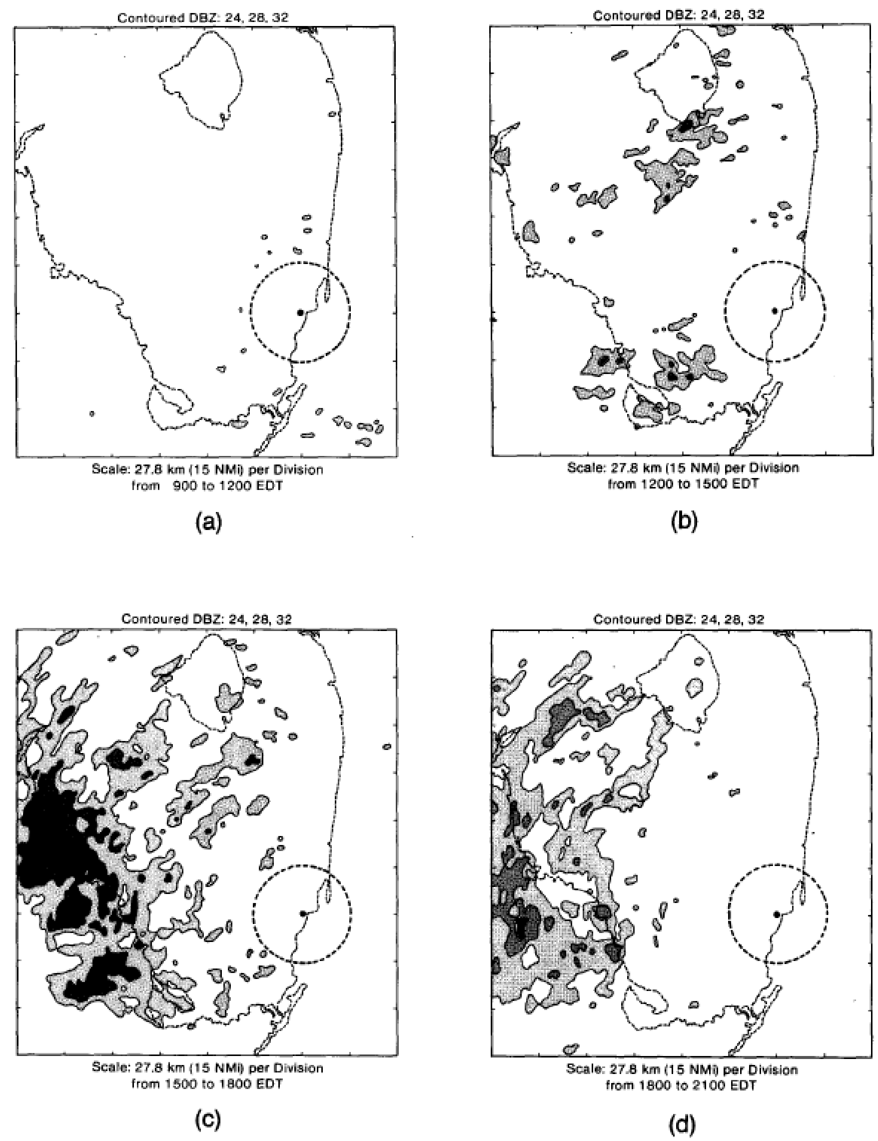



FIG. 3. As in Fig. 2 but for Type 2 days.

# Blanchard and López (1985)

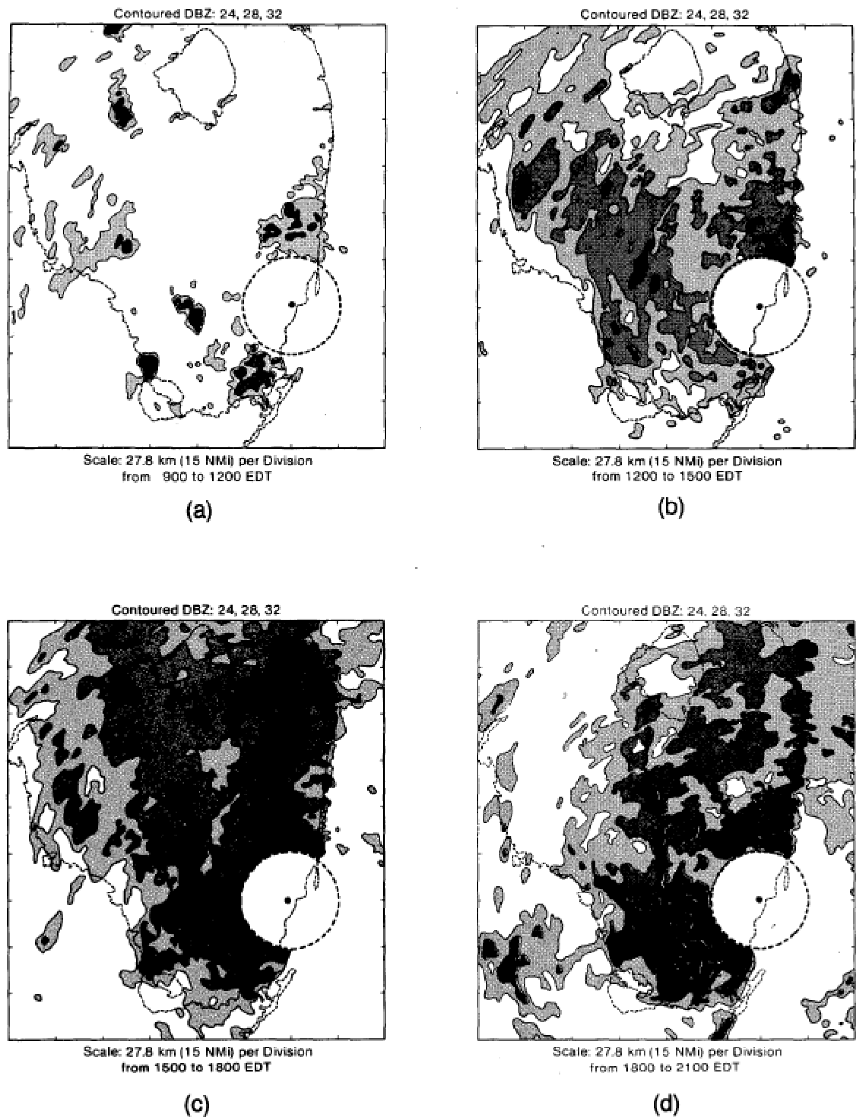



FIG. 4. As in Fig. 2 but for Type 3 days.

# Blanchard and López (1985)

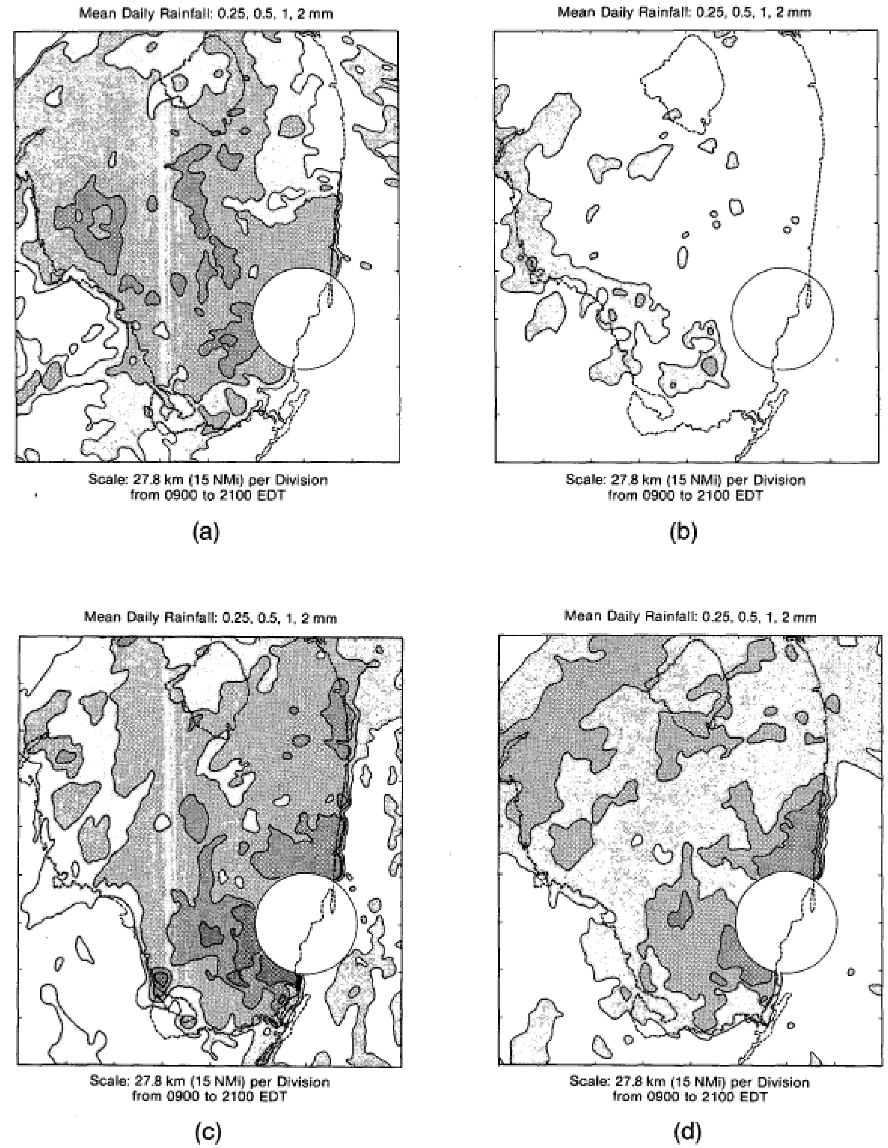



FIG. 5. Mean daily rainfall for (a) Type 1 days, (b) Type 2 days, (c) Type 3 days and (d) Type 4 days. Light shading is for 0.25 mm, medium shading is for 0.5 mm, heavy shading is for 1.0 mm, and darkest shading is for 2.0 mm rain depth.

# Blanchard and López (1985)

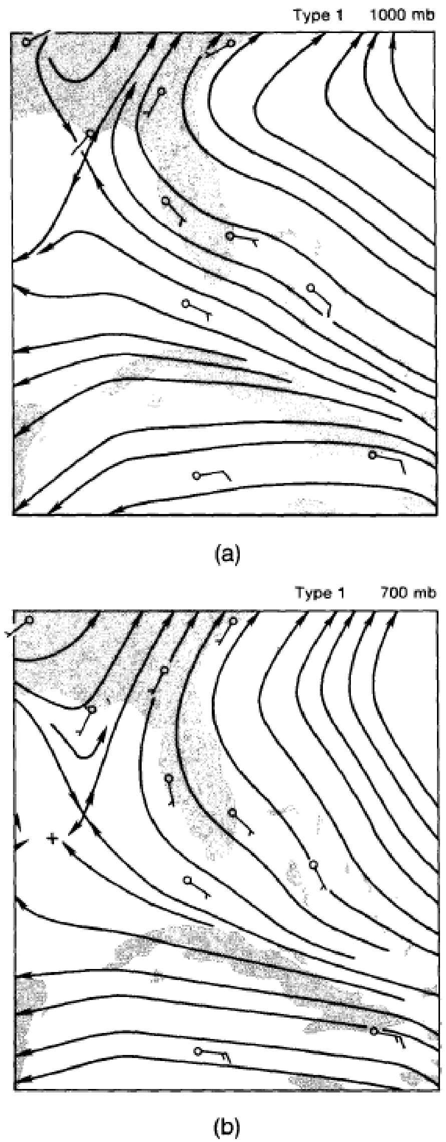



FIG. 11. Mean synoptic wind field for Type 1 days at (a) 1000 mb and (b) 700 mb. Full wind barbs are 5 m $s^{-1}$ and half barbs are 2.5 m $s^{-1}$.

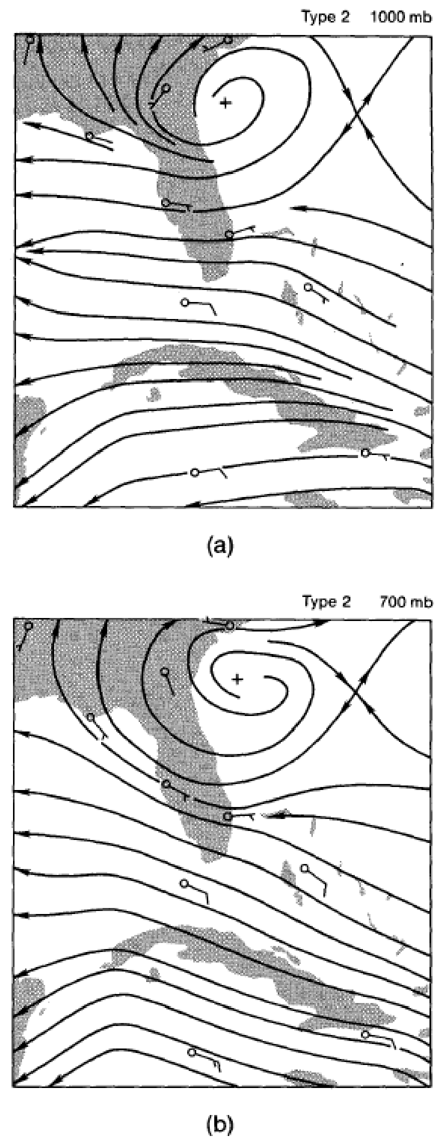



FIG. 12. As in Fig. 11 but for Type 2 days.

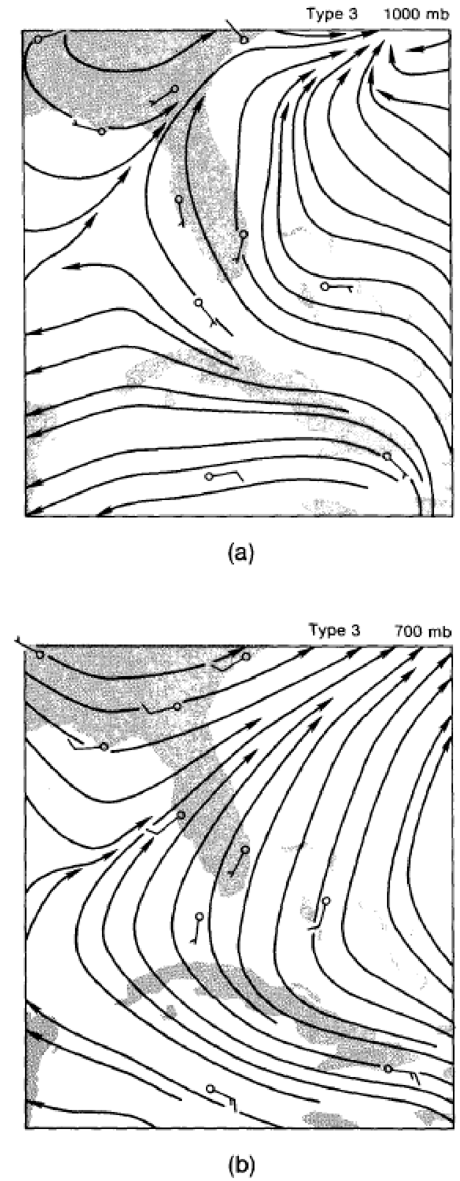



FIG. 13. As in Fig. 11 but for Type 3 days.

# Some Aspects of Florida Convective Rainfall

STANLEY L. ULANSKI[1] AND MICHAEL GARSTANG

*Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia 22903*

A dense network of rain gages in an area of 660 $km^2$ in south Florida was operated for the summers of 1971 and 1973. More than 3 times as much rain fell in this network in the summer of 1973 than in 1971. The two periods are examined in order to understand the controls in convective rainfall which produce such contrasting amounts. It is found that the total duration and intensity of rain was about the same in both years. Well-organized thunderstorms of large extent account for the bulk of the rainfall. These large storms occurred with a greater frequency in 1973 than in 1971. Days with single showers produced more rain than multishower days. The critical variable in determining convective rainfall amount is the size of the individual storm. These large storms appear to eliminate competition for the available moisture supply and are more efficient in converting that moisture to rainfall.

# Unlanski and Garstang (1978)

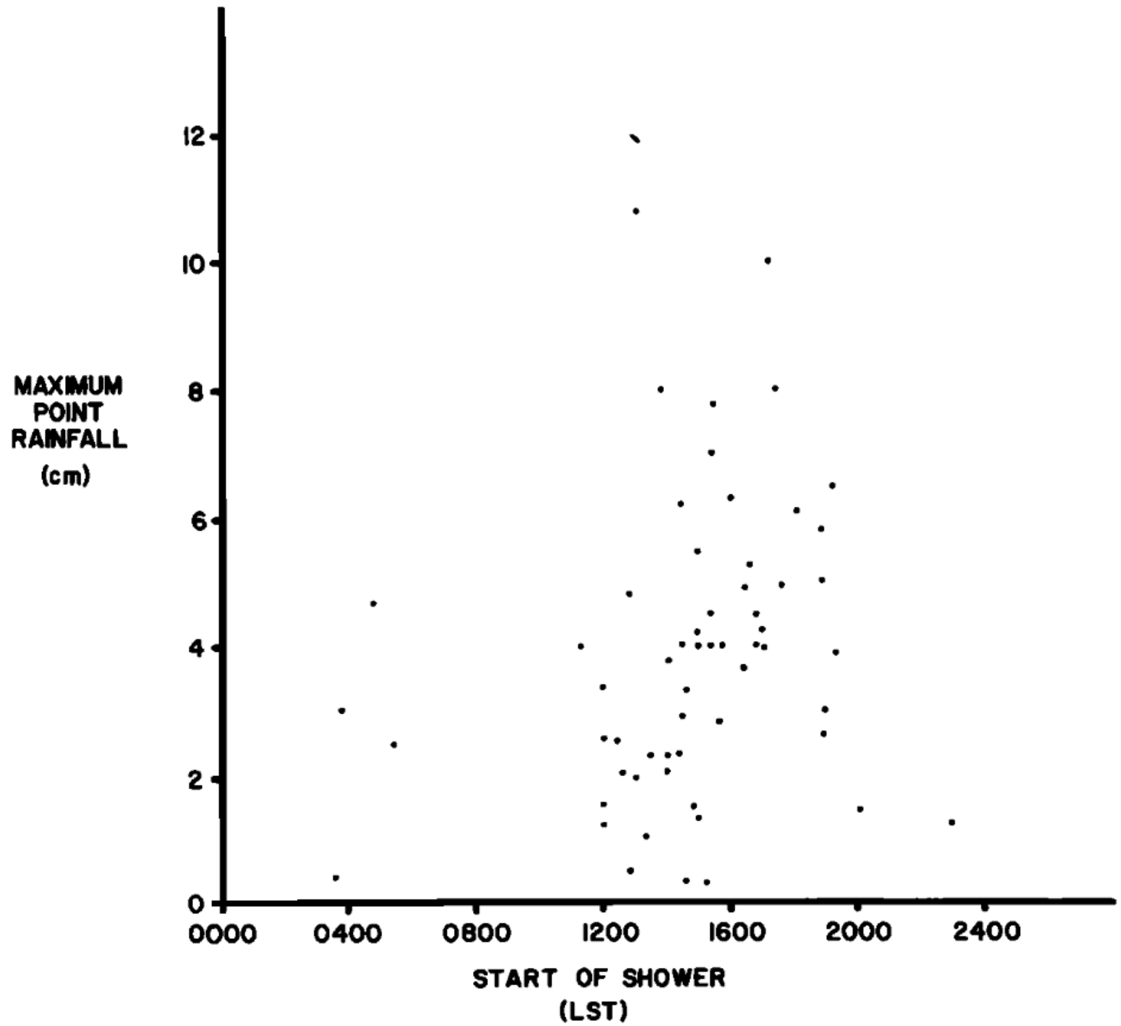



Fig. 3. Storm maximum point rainfall (SMPR) versus start of shower for 1971 and 1973, where the SMPR is the highest amount of rain accumulated in a single rain gage in the network over the lifetime of a single storm.

# Unlanski and Garstang (1978)

TABLE 1. Rainfall Amount for Single-Shower Versus Multishower Days

| Duration, min | Rainfall, cm | | $R_s/R_m$ |
|---|---|---|---|
| | Multishower Days | Single-Shower Days | |
| 60 | 20 | 100 | 5.0 |
| 120 | 55 | 170 | 3.1 |
| 180 | 80 | 240 | 3.0 |
| 240 | 120 | 320 | 2.7 |
| 300 | 170 | 550 | 3.2 |

TABLE 2. Six Cases of Velocity Convergence, Showing the Size of the Subcloud Area, the Moisture Supplied to the Storm, the Planimetered Rainfall Amount, and the Efficiency

| Date | Maximum Area of Surface Convergence, $km^2$ | Moisture Supplied, $\times 10^{11}$ g | Rainfall, $\times 10^{11}$ g | Efficiency, % |
|---|---|---|---|---|
| June 16 | 53.4 | 92.80 | 66.50 | 72 |
| July 17 | 10.7 | 7.96 | 2.93 | 37 |
| July 26 | 10.4 | 5.98 | 3.20 | 54 |
| July 31 | 10.0 | 4.16 | 2.25 | 54 |
| Aug. 5 | 4.7 | 1.35 | .61 | 46 |
| Aug. 12 | 2.2 | .54 | .29 | 54 |

# Unlanski and Garstang (1978)

SUMMARY AND CONCLUSIONS

A densely instrumented rain gage network has been used to determine the nature and structure of the convective rainfall regime over south Florida. In particular, differences in the characteristics of summertime rainfall between 1971 and 1973 were determined. The following features of the rainfall regime were observed.

1. Large well-organized thunderstorms accounted for the bulk of the network rainfall. These severe storms occurred at a higher frequency in 1973 than 1971.

2. The percent of rainfall duration over the entire experiment period was approximately the same in 1971 and 1973, though the area mean network rainfall was 3 times greater in 1973 than 1971.

3. The rainfall regime of 1971 was characterized by a relatively large number of small, weak showers. Often two or three of these showers would occur on a single day.

4. Days on which only a single shower occurred in the network yielded more rainfall than the multishower days for the equivalent rainfall duration.

5. The preceding three points combined lead to the conclusion that the critical variable in determining convective rainfall amount is size of the individual storm. The total time of duration of showers on multishower days is similar to the duration of single showers. Water yield, however, is double for the latter. We speculate that large-area showers eliminate all local competition for moisture, thereby generating a more efficient system. Small showers fail to draw in as much moisture despite the fact that they may collectively last as long as the large shower.

6. The rainfall intensity (amount/duration) is of secondary importance in accounting for the yearly differences in the total water supply over an area.

# References


Anderson, J. et al., 2004: The new GFDL global atmosphere and land model AM2-LM2: Evaluation with prescribed SST simulations. *J. Climate*, **17** (24), 4641-4673.

Ashby, S.A., M.A. Taylor, and A.A. Chen, 2005: Statistical models for predicting rainfall in the Caribbean. *Theor. Appl. Climatol.*, **82**, 65-80.

Blanchard, D.O., and R.E. López, 1985: Spatial Patterns of Convection in South Florida. *Mon. Wea. Rev.*, **113**, 1282–1299.

Céspedes, R.V., G.J. Holland, L.O. Mearns, and R.D. Loft: Decrease in the summer rainfall of the southern United States coast and the Caribbean due to climate change. *SOARS Proteges Research Papers Summer 2009*, University Corporation for Atmospheric Research (UCAR), Boulder, Colorado.

Curtis, S., and D.W. Gamble, 2008: Regional variations of the Caribbean Mid-Summer Drought. *Theoretical and Applied Climatology*, **94**, 25-34.

Magaña, V., J.A. Amador, and S. Medin, 1999: The midsummer drought over Mexico and Central America. *J. Climate*, **12**, 1577-1588.

Rauscher, S.A., F. Giorgi, N.S. Diffenbaugh, and A. Seth, 2008: Extension and intensification of the Meso-American mid-summer drought in the twenty-first century. *Clim. Dyn.,* **31**, 551-571.

Stephenson, T.S., A.A. Chen, and M.A. Taylor, 2008: Toward the development of prediction models for the primary Caribbean dry season. *Theor. Appl. Climatol.*, **92**, 87-101.

Ulanski, S.L., and M. Garstang, 1978: Some aspects of Florida convective rainfall, *Water Resour. Res.*, **14**(6), 1133–1139.